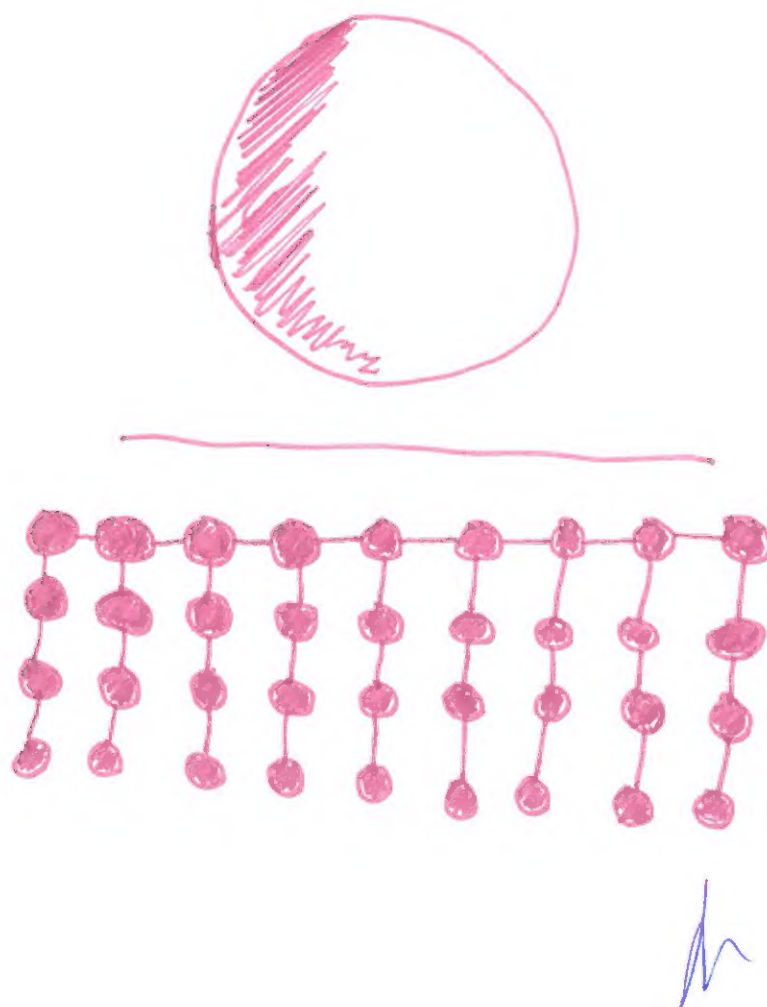


*The formation of the concept of reflex
in the XVIIth and XVIIIth centuries*
Georges Canguilhem

ed., trans. Camille Akmut
2024



II. rough schema
of a network
(macroscopic
above, microscopic
below)

[alternative: Golgi_{cut}]

0

Contents

Foreword	p. 4
Introduction	p. 6
Chapter 1 - Muscular movement, state of the problem before Descartes	p. 12
Chapter 2 - The Cartesian theory of involuntary movement	p. 30
Chapter 3 - The formation of the concept of reflex movement by Thomas Willis	p. 61
Chapter 4 - The igneous soul	p. 84
Chapter 5 - Decapitated animals and organic sympathies	p. 94
Chapter 6 - Unzer and Prochaska	p. 114
Chapter 7 - Historiography of the reflex in the 19th and 20th centuries	p. 138
Conclusion	p. 176
Appendix - Some texts of Willis	p. 180
Bibliography	p. 187

*To Mister Gaston BACHELARD, philosopher.
To Charles KAYSER, physiologist
in testimony of great gratitude.*

FOREWORD

It matters little to us to be or not held for a vitalist, whatever appreciation ^{one} ~~what~~ may wish to enclose in this adjective. Rigorously, the term of vitalist should only be used to designate a biological theory or a philosophy of biology, if the enterprise has a meaning for them, and not a philosopher of the biology, sole enterprise possible for a philosopher, but too often confused with the biology of a philosopher, monstrous project. To show interest in a family of spirits/minds and to make it appear alive, when many believe it to be dead, does not obligatorily conduct to a magical identification with it.

If thus we make the effort, in this present study as elsewhere*, to defend the biology of the vitalists against the accusation of aberration or of sterility, it is not at all that we think to be in possession of a vitalist key to problems posed to intelligence by life. We do not think to have any key, for the the good reason that we do not believe in the mysterious portals/doors of life. One can admit that life disconcerts logic without believing at the same time that one will be better off in dealing with it by renouncing to the formation of concepts, in order to go looking for some misplaced/lost key. And we believe also that a vitalist conviction does not have the privilege to engender in the biologist, before the problems that life poses to them, laziness and silliness. There are some example to the contrary.

This present work demanded a lot of research and reading from us. We began it in Strasbourg where we had available the considerable and, very luckily for us, easily exploitable resources of the Bibliothèque Nationale et Universitaire [National and University Library] and of the Library of the Institute of Physiology of the Faculty of Medicine. We pursued it more slowly and less easily in Paris.

Among the works used, there is one of which we must especially say a few words. We have discovered the existence in the course of our investigations, of the book of Franklin Fearing,

*trans. note: the previous ~~full~~ book of the author, *Connaissances de la vie* (1952).

Reflex Action, a study in the history of physiological psychology (1930). It was impossible for us to find this book in France, besides it was out of stock in the United States when we asked there for it. Thanks to the benevolence of the Rockefeller Foundation, we were able to obtain a microfilm, established by the care of the Academy of Medicine of New York. We wish to say here our gratitude. Even though we were only able to use this document after having collected the major part of our sources of information, it was useful to us, as much to complete them as to confirm or contract some of our own positions. This review which appears to omit nothing, from Aristotle to Sherrington and from Gallen to Pavlov, overflows naturally by much the delimited field that we explored directly. That's to say, that for the period of the XVIIth and XVIIIth centuries, it contains more names and references than our personal study whose intention is very different, subordinating history to a critical examination of a question of methodology. It is not that Fearing forbids himself from any critical judgment in the course of his expose. But this critique is formulated only from the point of view of the specialist, it is the critique that the psychological physiology of today holds on that of yesterday. Anyway this work is as indispensable on the question as it is practically inaccessible to the French reader.

We insisted on putting the last touches to our work at the Institute of Physiology of the Faculty of Medicine of Strasbourg, in order there to verify more easily many of our references. The quality of the welcome that we received always at the Institute by the Pr. Charles Kayser makes us regret sincerely today to not be better assured of the quality of this study which is, in great part, at least in its instruments and its locations of confection, a work of the Institute of Physiology of Strasbourg.

We insist to not omit from our thanks the Pr. Marc Klein, director of the Institute of medical biology of Strasbourg, whose precious competence in matter of history of medicine has been to us, often indeed, helpful.

We should indicate lastly that we have adopted, for most of the biographical and bibliographical dates, the data of the excellent *Medical Bibliography* of Garrison and Morton, indispensable instrument of the history of medical sciences.

INTRODUCTION

There is a lack of distinction in the studies of unequal lengths relating to the history of researches on the reflex movement, between the description of the phenomena of neuro-muscular automatism, the experimental study of anatomical structures and their functional links, the formulation of the concept and its generalization within a theory. Through this is explained the surprising divergences, among the historians of biology or the biologists composing brief historical overviews, as to the attribution to such or such author of the merit of originality or anticipation.

If we propose to undertake a historical and critical assessment¹ that takes into account the distinction of points of view too regularly confused, it is not merely with the aim of making good some bad, zealous enterprise based on erudition, but really with the aim of the lesson that can be drawn for the history of science and for epistemology. Indeed, the final reason of existence of discordant historical versions appears to be down to two prejudices that are fairly widespread. One concerns any science and consists in thinking that a concept can only first appear in the context of a theory or at least in a heuristic inspiration homogeneous with those inside of which the corresponding facts of observation will later be interpreted. The other concerns more specifically biology and consists in thinking that in this science alone the theories of mechanist style have led to fertile applications and positive acquisitions.

We know that, in the second half of the XIXth century, the reflex was universally regarded by the physiologists as the element of composition of all the animal movement, according to laws of complication that a mechanist conception of life would rob of any teleological value. On this pretended acquired fact, the works of Sherrington (1906), without forasmuch constituting a return to biological teleology, have carried out a decisive blow. The reflex is not, according to him, an elementary phenomenon, of linear or geometric simplicity, but the manifestation

¹trans. note : another play with language, *mise au point* and juxtaposed *points de vues*. A practice favored by Canguilhem and defining of his style. (C. shares the enthusiasm for word plays with hackers.) This dimension is lost here, as a good "hack" can't be produced by the translator. In other words, a challenge to others; similar to an equation to be solved under constraints.

by...
mechanist
biologist

more simple, that is to say less complex, of an integrative power proper/specific to the nervous system, through which the animal organism exists as a whole. The reflex is not anymore a unit of conversation of an elementary excitation/stimulus into an elementary movement. It is already a unification or a systematization through which a convergence of nervous influx, exciting or inhibiting, provokes a muscular synergy. The works of Bethe, of von Weizsäcker, of Goldstein, for the conclusions of which the works of Mr. Merleau-Ponty have procured a large audience in the French philosophical public (1), have reinforced the mistrust towards the dogma of the biological reality of the elementary reflex arc (2). It only subsists much today but in the manuals of secondary teaching/school manuals. But in the XIXth century, the mechanist theory, founded on the generalization of a concept whose elements of comprehension were fixed by 1850, resounded retroactively on the common conception that was made of its origins. A phenomenon that founded, with many others, but among them eminently, a mechanical explanation of animal life, seemed logically as if it could have only been discovered and studied through a biological mechanism. If the logic of the history of theories indicated a mechanist, the history of physiology named him, Descartes. This accord seemed to close the discussion, without anyone being able to know and even without anyone have wished to know if logic confirmed history or if it had indeed inspired it. From an incontestable fact, that Descartes proposed a mechanical theory of the involuntary movement, of which certain examples, very well described by him, are effectively what were to be called in the XIXth century reflexes, the conclusion was drawn, through a surreptitious anticipation of the future, that Descartes had described, named and conceived the reflex, since

(1) *La structure du comportement*, Paris, P. U. F., 1942.

(2) "The reflex in appearance the most uniform entails in reality inflections that accommodate it to the circumstance. The angle of reflection is never realized at the angle of incidence. It is enough to remind of the works of Goldstein and the remarkable part that Mr. Merleau-Ponty and Mr. Buyer have just drawn from it in favor of the thesis that we defend. Therefore subsists few theories of the reflex that are radically mechanist. Any reflex testifies to an adaptation at least limited. None justifies plainly its name, of optical resonance : none is entirely reflex." M. PRADINES, Douleur et finalité, in *Revue de métaphysique et de morale*, April 1947, p. 159-160.

See also a good summary of modern critiques of the notion of the reflex, from the point of view of neurology and of psychiatry, in the articles of Henry EY : Systeme nerveux et troubles nerveux, in *L'évolution psychiatrique*, 1947, p. 74-75 ; Les theories réflexologiques de Pavlov et la psychiatrie, *ibid.*, p. 206-209.

See finally on the limits of the explanation through the reflex in animal psychology, F. J. J. BUYTENDIJK, *Traité de psychologie animale*, chap. IX : "Les réflexes", Paris, P. U. F., 1952.

it was to explain all the phenomena on the order of those that he explained in his own way/fashion that the general theory of the reflex saw the light of day/was born.

been

It has seemed to us that little remained of such a historical painting, at the end of a tight reading of the biological oeuvre of Descartes, when this reading is more attentive to the truth than to the glory of Descartes — capable besides of supporting/sustaining without great damage such a reduction — and to the number of quarters of nobility which the mechanist theory of the reflex may wish to boast. To keep to the sole concept of reflex, as it could have been enunciated in 1853, when Pflüger had formulated for it what one still called then the "laws", it is certain that all the elements of its logical comprehension would remain unchanged, if one were to delete in thought the hypotheses and observations of Descartes anatomist and physiologist.

the

We think personally that in matters of history of sciences the rights of logic should not be erased before/in front of the rights of the logic of history. Such that before commanding the succession of theories according to the logic of their convenience and of their homogeneity of inspiration, one must first assure, in the presence of a given theory, where one searches to detect such or such implicit or explicit concept, that one has of it an idea from which all concern for internal coherence is not absent. Without this we would arrive at the paradox that logic is everywhere except in the thought of scientists and there can be a logic to the succession of doctrines in themselves indifferent to logic. Even if one holds for out of date the logic of non-contradiction, even if one replaces the term of logic with a term currently more prestigious, this won't change anything to the affair.* Even if doctrines are supposed to be dialectically engendered, it remains that norm of scientific theory is not the norm of a fabulation, dream or fairy tale. The theory in question, while there subsists of it almost nothing today in the order of principles, cannot be said false nevertheless but in reason of a judgment held over its principles, based on the links with their judged consequences, which leads to that the pieces of this doctrine are supposed to adjust themselves somehow than through inconsistency, and that the concepts there are composed differently than through juxtaposition.

We are then conducted to look for the conceptual [af]iliations in a different direction. Instead of asking which author is the one whose theories of involuntary movement prefigure the theory of the reflex during the XIXth century, we are rather led to ask what a theory of muscular movement

* trans-note: reference to Cavailles or latest developments in logic in the first half of the 20th c. (post-Frege, Russel, Wittgenstein...)

and of the action of the nerves must entail in order for a notion, like the one of reflex movement, covering the assimilation of a biological phenomenon to a phenomenon of optics, finds there a sense of truth, that is to say first a sense of logical coherence with a group² of other concepts. If this concept, logically outlined or formed in such a context, is found later/subsequently captured by some theory that uses it in a context and sense different from the first, that does not make it so that the concept is condemned to be no more, in the initial theory, but a word empty of meaning. For there ^{are} some theoretically polyvalent concepts, like the reflection and refraction of light relative to corpuscular theory and to wave theory. It is excluded, in any case, that the vigor of a concept in a given theoretical terrain can constitute a sufficient presumption to limit to theoretical terrains of same composition the research of its locations of birth.

Thus we did, not surely discover Willis, named sometimes already in the XIXth century by the physiologists who had paid some attention to the history of the reflex, but searched to confirm Willis in a title that was only granted to him hitherto, without arguments of sufficient rights to bring to an end any contesting or rivalry. In order to make the demonstration of the solidity, of the duration, we do not say of the invariability, of the concept formed by Willis, to establish the filiation between Willis and the first physiologists to whom their successors of the XIXth century have recognized the truthfully scientific means and the merits, Marshall Hall and Johannes Muller, we had to clear/clarify the content and the sense of certain works and to retrace the history of certain problems over a century and a half. We also had to make the assessment of knowledge concerning the muscle and nerve during the times of Descartes, which forced us to start from the authors whose texts were at our disposal, Aristotle and Galen, on which we could depend/rely without going through the doxographs.

One will thus find in our study a summary of the evolution of biological knowledge concerning the physiology of the nerve and of the muscle, from Aristotle to the end of the XVIIIth century. The dissociation of studies concerning the one and the other organ is impossible until this period. The nerve was first studied based on its relation with the muscle. It is not that, on ~~the~~ its side, the problem of the sensory ways is not as old as the pain of Man. But the interest granted to movement is both more imperious and large. The movement is for

²trans. note : group here, or *ensemble* i.t.o., has connotations of group theory due to a, wider, context of concerns expressed over logic in this introduction, in addition to elsewhere; and as we have argued the connection to Cavailles can never be dismissed certainly. (See also the last page here.)

they

themselves

Man the only sign to which ~~it~~ recognizes, for any living [being] other than ~~itself~~, the presence of feeling/sensitivity. Impassibility is first immobility. To live, in the animal mode, is to move. That is why Bichat noted that when locomotion and movement in general reduce progressively, in the course of aging, the organism returns to the condition of plant life "which only lives inside and for which all nature is a silence" (1). It is hence for a reason that touches on the essential specificity of animal life that the history of the reflex and the history of the contraction of the muscle are so intimately linked.

in

~~This~~ this reason is added another which has to do not only with the essential specificity but also the eminent dignity that rightly or wrongly Man attributes to human life. Yet the conscience of dignity is not only consciousness of a fact of secession but especially of a right of domination. The essence of dignity is the power to command, it is the will. Therefore the attention brought to delimiting among the movements those that are only animal and those that are expressly human, voluntary and reasonable. The distinction of voluntary movement and of involuntary movement has not yet disappearing from the works of physiology. The voluntary movement offers however some resistance to the enterprise of the physiologist if they wish to preserve its original signification in the frame of a purely objective explanation. In the definition that they give are concealed some traps of subjectivity. It is easier to displace them than to destroy them. In any way, the physiologists are more at their ease when they speak of reflexes. The number of pages that they dedicate to them testify enough of this that the physiology of the automatism is easier to do than that of the autonomy.

(1) *Recherches physiologiques sur la vie et la mort*, 1st Part, art. X, § 1 : La vie animale cesse la première dans la mort naturelle. [t.n. Animal life ceases first in natural death.]

FIRST CHAPTER

MUSCULAR MOVEMENT, STATE OF THE PROBLEM BEFORE DESCARTES

In the treatise *De musculi fabrica* (1614) Fabricius of Acquapendente makes the remark that Aristotle (384-322 B.C.)¹¹ never uses the term muscle ($\mu\upsilon\varsigma$)¹² in his works on the walk¹³ and movement of animals. One only finds, he says, the term once in the *Problems*¹⁴ – which is confirmed by Bonitz' Index¹⁵, with respect to 885 a 37-38 – and even then the possibility remains that this may be an interpolation.¹⁶

In fact, Aristotle only cites the bones, the tendons and the nerves (1) as organs responsible for movement in the animal body. When he distinguishes the various plastic elements – we would say the tissues – one from another his interest concerns the blood, the bones and the flesh ($\sigma\acute{\alpha}\rho\chi\eta$). In brief, never once does he mention a special formation that would correspond to what we have since given the name muscle.

In the treatise *On the movement of animals* (2), having distinguished between movement taken as a whole and movement of the parts, he is preoccupied with making his explanation of the movement of the members fit inside the general frame[work] of his physical and metaphysical theories

(1) Aristotle designates by the word of nerves ($\nu\epsilon\upsilon\rho\alpha$) the tendons or the ligaments (see especially : *Historia an.*, III, 515 b 13-15). Cf. L. PHILIPPSON, *De internarum humani corporis partium cognitione Aristotelis cum Platonis sententiis comparata* (Berlin, 1831), p. 12-14 ; — G. POUCHET, *La biologie aristotélique* (*Revue philosophique*, 1884, II, p. 537) ; — J. SOURY, *Le système nerveux central, Structure et fonctions, Histoire critique des théories et des doctrines* (Paris, 1899), I, p. 216. — E. BASTHOLM, *The history of muscle physiology* (1950, p. 41-52).

(2) We remind that W. JAEGER, editor of *De animalium motione* and of *De animalium incessu* (Teubner, 1913), has established against Zeller the authenticity of the first of these treatises. Cf. *Das Pneuma in Lykeion* (*Hērmes*, t. XLVIII, 1913), p. 31 sq.

¹¹trans. note : This history, like many Western ones, begins with the Ancient Greeks; which some may find disappointing in times where world histories are popular. Did Arabic or Chinese medicine contain nothing useful about the muscle, reflex or relevant body-soul philosophies? Erwin Ackerknecht, who published his *A short history of medicine* the same year, and gave space to other cultures (only starting with the Greeks in chapter five), wrote : "Ancient Greek medicine is incomparably closer to modern medicine than any other historical form of medicine." ('Greek medicine'). Charles Singer faced this issue and dedicated a chapter to 'Before Aristotle' in *Greek Biology and Greek Medicine*.

¹²trans. note : We type out the Greek letter by letter in math mode... (at some point this becomes impossible or too laborious due to the lack of accentuation, punctuation marks, etc.)

¹³trans. note : la marche.

¹⁴trans. note : *Problemata*.

¹⁵trans. note : C. means the *Index Aristotelicus* of Hermann Bonitz. The relevant section is from page 440 (M), the entry found on pp. 478-479 in the edition we use (4. *musculus*).

¹⁶trans. note : Aristotle uses $\mu\upsilon\varsigma$ in *Historia animalium* [Books I, III, VIII, IX], *Mirabilium auscultationes* and *De interpretatione* in 7 occurrences - respectively five, one and one times, based on the computer search enabled by the Perseus project. In *The Works of Aristotle*, (vol. IV), for his English translation of *Historia animalium* Thompson chooses expressly the word muscle ("the muscles of the loins", twice), in a passage where Aristotle quotes Polybus, student of Hippocrates.

alternatively.
of w.h.'s
popularity.

about movement.

In all movements, one must distinguish between what moves and what is moved¹⁷, in other words an immobile which is active and a mobile which is passive. It is thus necessary to examine how the soul moves the body and which immobile active principle is behind the movement of the body. The good that the animal seeks is the immobile motor ; the desire, itself moved¹⁸, is what moves. The organ by which the desire moves the body and which moves being moved, is the articulated member. Here also, one part is at rest while the other is in motion, for instance in the flexing of the forearm over the arm. Movement's instruments are the bones and the nerves (*De motu an.*, 701 b 9-10 ; *De Natura*, III, 433 b 13 sq.)¹⁹. Bones are pulled by nerves, just as the arms of a catapult by tensor cables (1). But in the members' movement the motor which is immobile is only so relatively. Yet every relative requires an absolute. It is thus necessary that the *primum movens* resides in some principle (*De motu an.*, 702 a 21-22).

It's the heart that happens to be the absolute site of movement, the central pivot (*ibid.*, 703 a 13-15), the corporal point where the soul communicates to the organism life, sensibility and movement (*De partibus an.*, 665 a 10-15). The heart is origin and principle, both anatomically and functionally (2). The heart is the origin of all the veins (*De part. an.*²⁰, 666 a 32-33), in which it pours²¹, like a source, the blood which it does not receive from anywhere else (*ibid.*, 666 a 7-8). It is the origin of the nerves, dispatchers of movement (*ibid.*, 666 b 13-15 ; *Historia an.*, III, 515 a 29).

It's his metaphysical theories, according to which any movement by a mobile needs an original immobile source, a primordial principle of movement that is transcendental to the object moved, that lead Aristotle to confer to the heart this eminent condition, a prerogative that is its own among all the parts of the body. Transposing, by opposing it, the Platonic image of the head, which is to say the brain, as the citadel of the human body (*Timaeus*, 70 b)(3),

(1) POUCHET (*op. cit.*, *Revue philosophique*, 1885, I, p. 47) and GOMPERZ (*Les penseurs de la Grèce*, trad. REYMOND, 1911, t. III, p. 180-181) say²² that Aristotle views²³ the organism in motion as a puppet²⁴.

(2) On the heart in Aristotelian biology, see L. PHILIPPSON (*op. cit.*, chap. VI, p. 23) ; G. POUCHET (*op. cit.*, 1884, II, p. 540) ; J. SOURY (*op. cit.*, I, p. 113-14) ; LE BLOND, *Introduction au Livre I Des parties des animaux* (Paris, Aubier, 1945), p. 33 note, and p. 75.

(3) Cf. A. E. TAYLOR, *A Commentary on Plato's Timaeus* (Oxford, 1928), p. 502-03. It is, it seems, Alcmaeon of Croton who first associated with the the brain the power to feel²⁵ and who has, on this point, inspired Plato. On this see : P. M. SCHUHL, *Les premières étapes de la philosophie biologique*, *Revue d'Histoire des Sciences*, July-September 1952, p. 212.

¹⁷trans. note : "ce qui meut et ce qui est mu".

¹⁸trans. note : "ému".

¹⁹trans. note : *an.*, often used by the author, because often a title by Aristotle, is an abbreviation for *animahum*. Connected to this, most experiments conducted for knowledge about the body, we understand from the text, were on animals. Castiglioni had the following to say on this point : "The anatomical knowledge of the Hippocratic school, as far as can be judged, is based on experience with animals. (...) The scanty knowledge in all the fields of anatomy, except the bones, about which they had accurate information, as is shown by the marked development of bone surgery, proves that examination of the cadaver was almost unknown. Nerves and tendons were confused with muscles, often also with blood vessels" (*A History of Medicine*).

²⁰trans. note : *De partibus animahum / On Parts of Animals* (as Singer also translates it, e.g.).

²¹trans. note : déverse.

²²trans. note : disent.

²³trans. note : se représente.

²⁴trans. note : marionnette

²⁵trans. note : sentir.

Aristotle views the heart as the Acropolis of the organism (*De partibus an.*, III, 670 a 26).²⁶ The heart is as an animal inside the animal (*ibid.*, III, 666 b 16). In the same way that the animal distinguishes themselves from the mineral and the plant²⁷ in apparent ways, through their independence and autonomy, saying of the heart that it is like another animal inside the animal means affirming its autonomy from the superior power. The heart is also what forms first inside the embryo. Not only does observation reveal this fact, but from the reasoning derives its necessity. In all order of things, what forms last also perishes first. And thus what in the organism dies last must be formed first (*De generatione an.*, II, 741 b 14 sq.). It's from the biology of Aristotle that comes the formula, classic since Harvey, which defines the heart : *primum movens, ultimum moriens*²⁸. The heart is thus the principle of life and movement, from the - triple - chronological, logical and ontological point of view. A consequence of this, both imperious²⁹ and unexpected is that, according to Aristotle, the heart is never afflicted by serious diseases, and this appears to follow from its functions, or rather obligations, as a primordial motor (*De part. an.*, III, 667 a 34). A chief isn't allowed to have failures. There it is : rooted in its origins, one of the fundamental dogma of physiology until Harvey, and which by the way will not collapse immediately - Descartes' strange attachment to this notion being the best testimony - under the assault / the blows that were directed against it.

The heart's movement thus necessarily transcends the movement of the members, which are dependent on it : This movement is said to be involuntary (*ἄκούσιος*), that is wholly outside of the action of the will³⁰, and in that way distinct from non voluntary movement (*οὐχ ἄκούσιος*³¹), which is to say the kind of movement that, without being so habitually, can in certain cases be regulated by will, as are sleep, wake/the state of being awake³², respiration (*De motu an.* 703 b 3-9). The movement of the heart requires an entirely different explanation from muscular movement. The heart is the home³³ of animal heat³⁴ (*De part. an.*, III, 670 a 24).³⁵ This original fire, is a divine fire, which is to say a stellar one, because the soul, as much as it requires a corporeal support, demands something more divine than any of the terrestrial elements (*De generatione an.*, II, 736 b 30 ; 737 a 6). This vital fire is ether (*De Caelo*, I, 270 b 24), of which, according to Aristotle, the etymology provides the essence (*ἄετι θέω*) : eternal movement (1).

(1) What has [just] been said goes for animals that have³⁶ blood. In the others, there is a part of the body homologous to the heart, but we have no need to cover this here.

²⁶trans. note : for a modern exposition of this debate, without philosophical apparatus or jargon, but also without precise reference to primary sources, see e.g. Bynum, *The History of Medicine*, p. 9. (Plato followed Hippocrates.)

²⁷trans. note : le végétal.

²⁸trans. note : first to move, last to die.

²⁹trans. note : impérieux.

³⁰trans. note : la volonté.

³¹trans. note : literally not [*οὐχ*] voluntary...

³²trans. note : la veille

³³trans. note : foyer. (Double, common meanings of home and fireplace.)

³⁴trans. note : "la chaleur animale".

³⁵trans. note : A basic question - perhaps too obvious, or ignored because so - not answered outright by C. is : Why the Ancients' preoccupation with the center or seat of heat in the body? As Castiglioni simply put it : "The essential factor in life is heat" (*A history of medicine* [1947], ch. IX 'The golden age of Greek medicine').

³⁶trans. note : pourvus.

(This actually happens later: through Cicero at the end of ch. 4.

The movement of the heart, per the *De respiratione*, is triple : palpitation, pulse, respiration. By palpitation one must understand the clash/pounding³⁷ of the heart against the thorax. The pulse, which is distinct, is the perpetual movement of dilation and retraction, analogous to the beating of an abscess full of pus, and due to the expansion, under cardiac heat, of humour³⁸, born from digestion, which in the heart constantly transforms into blood. The pulse is thus literally the effect of an ebullition (479 b 30). We will find this theory again in Descartes' work, hence its historical significance/importance (1).

Remains to determine by which intermediary, the central principle of life and movement, enters relations³⁹, in the opposite direction, with the totality of the organism. Here we find one of the most obscure parts of Aristotelian biology and psychology. All animals possess an innate air/wind/breath⁴⁰ (σύμφυτον πνεῦμα), of which the heart is the source, capable of dilation and contraction, and therefore able to communicate movement through pushes or traction (*De motu an.*, chap. X). Breath is thus the first instrument of the soul both in terms of being the site of *sensorium commune* (2) as well as source of movement. But in the already cited *De generatione animalium*, II, it is said that the vital heat which renders sperm fertile and inhabits the living is not constituted by fire, nor derived from fire, it is the pneuma enveloped by the foam⁴¹ of sperm and more precisely the immanent principle, similar to ether, the quintessence. We are thus precisely dealing with the following problem : the heart is the source of σύμφυτον πνεῦμα⁴², it is also the source of animal heat ἀρχὴ της θερμότητος (*De part. an.*, III, 670 a 24), in such a way that breath and animal heat find themselves to be at once innate and of transcendental nature with relation to the physical organism and its composing elements, the πνεῦμα⁴³ being added to the embryo from the outside (θύραθεν) through the sperm (3). It is likely/plausible⁴⁴ that Aristotle composed/combed⁴⁵

(1) DESCARTES cites/quotes texts from *De respiratione* in *La description du corps humain* by contesting to Aristotle the merit of having said the truth other than through chance : "Hence his opinion hasn't been followed on this by anyone, notwithstanding that he has been blessed of a following in many others less likely/plausible " (Ad.-T., XI, p. 245). Descartes' zeal with regard to an Aristotelian opinion - once isn't custom - isn't particularly commendable⁴⁶.

(2) Cf. RODIER, *Traité de l'âme d'Aristote* (Paris, Leroux, 1900), t. II, p. 322-334.

(3) On the exposition and discussion of this difficulty see : a) J. B. MEYER, *Aristoteles Thierkunde*, Berlin, 1855, p. 409-13 ; b) W. JAEGER, *Diokles von Karystos*, Berlin 1938, p. 202-203 ; c) DE CORTE, *La doctrine de l'intelligence chez Aristote*, Vrin ed., 1934, chap. XII ; d) The interprétation by De Corte is contested by VERBECKE, *L'évolution de la doctrine du Pneuma*, Desclée de Brouwer ed., p. 47-49 and 60, with reference to the book of NUYENS, *Ontwikkelingsmomenten in de Zielkunde Van Aristoteles*, Nimègue-Utrecht, 1939.

³⁷trans. note : choc.

³⁸trans. note : l'humeur. (In the old, physiological sense, whose etymology is liquid or fluid.)

³⁹trans. note : entre en rapports

⁴⁰trans. note : souffle inné. (C. here refers to the pneuma.)

⁴¹trans. note : écume.

⁴²trans. note : pneuma (above).

⁴³trans. note : pneuma...

⁴⁴trans. note : vraisemblable.

⁴⁵trans. note : "compose".

⁴⁶trans. note : louable.

in this obscure theory two conceptions of the animation of the living through heat : the theory of the physiologists of Ion which makes animal heat come from the universal fire, intermediary between air and ether, and for whom respiration is the fundamental vital phenomenon, and the theory of the doctors from the School of Sicily, systematized by Diocles of Carystus, particularly concerned with the phenomenon of digestion and coction, and which considers the heart as the principal dispatcher, from the liver on, of internal heat (1). For Aristotle, just as for the Sicilian doctors, respiration plays a regulatory role through refrigeration. The lung is the antagonist of the heart. In this function the heart is second. Aristotle is so far from attributing any positive traits to the brain in animal motricity/motion⁴⁷ that he only recognizes the sole negative role of moderating the excesses of heat with cardiac origins, organic origin of life and movement (*De part. an.*, II, chap. VII). Descartes won't attribute to the lung any other role (2).

→ [the] heat of cardiac origin (altern.)

* *

With Galen (131-200) we are dealing with a physiologist doctor of an entirely different formation than Aristotle. To be sure, his physiological theories are no less suspended in metaphysics than are those of the Stagirite. One could even say that he uses multiple metaphysics : that of Plato, that of Aristotle, and sometimes that of the Stoics. In medicine, he is an Hippocratic. He has nothing of an empiricist. But even though his observations and research are no more free of a systematic view of the world and of life than are Aristotle's, he is at least freer in his handling of narratives/stories and testimonies and with regard to logical constructions. He is a man of experimentation : "If no more than Aristotle, the doctor of Pergamon never dissected a human cadaver, he sacrificed at least hecatombs of mammals to experimental physiology, of which he is the father (3)."

(1) Cf. T. Clifford ALLBUTT, The innate heat, in *Contributions to medical and biological Research, dedicated to Sir William Osler*, New York, 1919, vol. I, p. 219-225.

(2) *La description du corps humain* (Ad.-T., XI, p. 236). In the *Traité de l'homme* (ibid., XI, p. 168) Descartes attributes also to the respiratory air, mixed to the blood before it drops in the left concavity⁴⁸ of the heart, a role in the embrasement/flare-up⁴⁹ of the blood.

(3) J. SOURY, *op. cit.*, I, p. 208. See the whole chapter on Galen, p. 259-309. — GALEN, *De placitis Hippocratis et Platonis*, VII, 3, himself speaks of his innumerable vivisections, in *Opera omnia*, ed. Kühn, t. V, p. 604.

⁴⁷trans. note : motricité.

⁴⁸trans. note : concavité.

⁴⁹trans. note : embrasement.

As for the problem which concerns us, Galen is, for the next centuries, the physiologist who identified the muscle as the organ of voluntary movement and located its functional origin within the brain, where the nerves have their anatomic origins. On these specific issues, Galen benefited from the discoveries of his Alexandrian predecessors, especially those of Herophilus and Erasistratus (first half of the IIIrd century B.C.). They, without yet discriminating very precisely the nerves from the tendons and the ligaments, do distinguish motor nerves and sensitive nerves whose origins they assign to the encephalon⁵⁰ and the ~~bone marrow~~/spinal cord⁵¹ (1). Galen sees in these discoveries a confirmation of the doctrines of Plato and of Hippocrates on the cerebral seat⁵² of the reasonable and voluntary soul (2). And he himself adds further support to them / gives them further strength through the experience of the neurosurgeon. If, in the course of a trepanning/trepanation, we compress⁵³ the brain with the *μενιγγοφύλαξ* (that is to say the valve interposed between the skull and the dura mater in order to protect it from actions/infringements⁵⁴ of the scissor), we deprive the patient of feeling and voluntary movement (3). He finds⁵⁵ that the section of the ~~bone marrow~~/spinal cord leads to the destruction of sensibility and movement in the parts of the body that are below that section. Finally, Galen differentiates⁵⁶ for the first time the nerve, the tendon and the ligament (4).

The work of Galen⁵⁷ that is expressly of greatest interest to us is *Περὶ μύων Κινήσεως* (*De motu musculorum*). In Book I, the muscle is recognized as the organ of voluntary movement. The nerves which implement themselves into the muscles are born in the heart and the ~~bone marrow~~/spinal cord. Without the integrity of the nerve, no movement in the muscle. The nerve, sectioned, compressed, ligatured, deprives the muscle from feeling and movement. Keep in mind the importance of the protocol of such experiments. The ligature of the nerve, practiced by Galen, is an experimental gesture/act whose repercussions on theories regarding the structure and functions of the nerves are considerable until the beginning of the XIXth century. A unique interpretation follows from this practice, namely that the nerve has the structure and the functions of a pipe⁵⁸ conducting towards the muscle a fluid whose ligature interrupts the influx (5).

(1) *De placitis H. et P.*, VII, 3 ; KÜHN, V, p. 602-03.

(2) *Ibid.*, II, 8 ; KÜHN, V, p. 278. Cf. PLATON, *Timaeus*, 73 d. Galen ignores or forgets Alcmaeon of Croton.

(3) *Ibid.*, I, 6 ; KÜHN, V, p. 186. HALLER cites also this text of Galen in the *Elementa Physiologiae*, 1766, t. IV, liv. X, sec. VII, § 15.

(4) *Ibid.*, I, 9 ; KÜHN, V, p. 204.

(5) "The paralyzing effects of a ligature are not permanent, unless the disorganization of this conductor has been the consequence ; in the contrary case, the muscular paralysis, as well as the insensibility in the parts located below the injured⁵⁹ point, dissipates/clears⁶⁰ when the constriction ceases. The physiologists attached great importance to this fact, when they attributed the nervous actions to the flux of a fluid going,

next p.

⁵⁰trans. note : encéphale.

⁵¹trans. note : moelle épinière.

⁵²trans. note : siège.

⁵³trans. note : comprime.

⁵⁴trans. note : atteintes.

⁵⁵trans. note : constate.

⁵⁶trans. note : distingue.

⁵⁷trans. note : following developments or paragraphs are dedicated, each, to the work of Galen cited : Book I, Book II, followed by a comparison between Galen and Aristotle.

⁵⁸trans. note : tuyau

⁵⁹trans. note : lésé

⁶⁰trans. note : se dissipe

< Here insert the much later note on moelle osseuse vs. ... > p. 125 n. 9
Former

The force which is in the nerves follows from⁶¹ their origin, the supreme principle. Through the section of the nerve, the distal part loses all possibility of moving or feeling. Therefore the nerves conduct, like streams⁶², to the muscles their abilities, from the brain onward like a source. Through this the muscle becomes an animal or psychic⁶³ organ. The muscle also gets from the heart an artery, and from the liver a vein. Through this the muscle becomes only a natural or physical organ. The movements of the artery and of the vein, for example the pulse, are natural and involuntary. The movements of the muscle are animal and psychic, which is to say voluntary. The muscles have only one, active, movement, the contraction. The opposite movement is the active movement of the antagonist muscle⁶⁴.

In Book II, Galen asks himself which is the sign of voluntary motor⁶⁵ operations (*καθ' ὁρμήν*). To be able to stop doing what one is doing when one pleases, and to start doing what one was not doing, that's what voluntary movement is. The ability to slow down or accelerate, to make what one is doing more frequent or more seldom, is another sign. For example, one cannot modify the movement of the heart or arteries, these operations ~~are~~ not fall within / do not belong to⁶⁶ the soul but to nature. On the contrary, the movement of the legs can be accelerated, delayed, stopped, resumed, in every aspect it is directed by reason. Galen like Aristotle meets the problem of involuntary movement. It is clear that certain movements, apparently involuntary, like respiration, are dominated by reason. But what remains obscure is the reason why we don't always apply our spirit to the majority of voluntary acts. An example invoked is the behavior of those who are afraid or drunk. They don't recall the acts that they have performed in that state because they haven't applied their spirit to them. The soul can only remember when it has been distinctively hit, which supposes application on its part. As a consequence, we can breath during our sleep without recalling, on waking up, that we did so

alternately⁶⁷, from the brain to the periphery of the organism, alternately from the periphery towards the center inside a system of capillary canals constituted by the nerves..." H. Milne EDWARDS, *Leçons sur la physiologie et l'anatomie comparée de l'homme et des animaux*, t. XIII, Paris, Masson, 1878-79, p. 19, n. 2. In fact, the ligature does interrupt the flow of a fluid, but it is⁶⁸ the blood in the artery nourishing the nerve / arterial feeder of the nerve. Same remarks on the historical importance of the ligature of the nerves, in RICHET, *Physiologie des muscles et des nerfs*, 1882, p. 508.

⁶¹trans. note : découle.

⁶²trans. note : ruisseaux.

⁶³trans. note : psychique.

⁶⁴trans. note : C means the act of de-contraction?

⁶⁵trans. note : motrice.

⁶⁶trans. note : relèvent.

⁶⁷trans. note : tantôt ... tantôt.

⁶⁸trans. note : s'agit.

The example of the insane is further invoked.
(altern.)

voluntarily. Another example invoked, the insane. Elsewhere, from the moment that will can suspend respiration who would wish to deny that respiration is voluntary?

Hence having shifted the principle of all movement from the heart to the encephalon was Galen's own merit. Therefore also the number of attacks directed against Aristotle. E. Zeller pretends that Galen cites Aristotle 600 times in his work. Most of the time it's to attack him, notably in Book I of *De placitis Hippocratis et Platonis*. In Book II of that same work, it's Chrysippus who is violently singled out for having, as had / in the image of Plato, located inside the heart the will, principle of intentional and reasoned movement, the directing soul (*ἡγεμονικόν*). These two books therefore take up again, in polemic fashion, the entirety of the dogmatic theories exposed in *De motu musculorum*. They are handled again, but more rapidly, in Book XVIII of *De usu partium*.

Undoubtedly, concerning the problem of movement, Galen's anatomy and physiology are more accurate and more modern than Aristotle's. To see, in the muscle, the proper organ of movement and to connect its functions with the central nervous system, these are definitive gains⁶⁹. But one could be inclined to find an analogy in the explanations provided by these two authors for the mechanism itself of movement. Do not both consider that all movements are excited by an internal anatomical center, site of a psychic power conceived as an absolute principle, even as they disagree on the location of this center? Out of which would follow, for one as for the other, the same difficulty of explaining movements by organs that are not subjected to will and for example also the similarity of their opinions on the structure of the heart, stored⁷⁰ among the viscera⁷¹, and its movement, unique amongst organs.

There is however a profound difference between Galen and Aristotle and which has mainly to do with the encounter of the Hippocratic and stoic influences in the case of the former. According to Aristotle, all movement is suspended on a first/prime⁷² immobile motor. In nature all movement is suspended, through aspiration and imitation, on the supernatural act. In the most perfect of terrestrial animals, Man, there is a soul which has come to the embryo from outside, which is related to⁷³ the divine ether, the soul from the stars. If, thus, this muscular movement is of central origins, this center must be linked to some transcending super-nature. The movement is the transition from power to act; but the act is anterior to the power.

⁶⁹trans. note : acquisitions.

⁷⁰trans. note : rangé.

⁷¹trans. note : viscères.

⁷²trans. note : premier.

⁷³trans. note : apparenté.

The Aristotelian psycho-physiology, apparently dynamist⁷⁴, has its foundation in an ontology of rest.

According to Galen, movement is truly the expression of an internal spontaneity. Here we are really dealing with a [case of] dynamism. On one hand, the Hippocratic intuition of life encloses the pre-sentiments of a biological energeticism/energism/energetics (trans. note : énergique (noun).), like Radl said (1). On the other hand, all movement, according to the stoics, is the manifestation of a tension (τόνος), of which the *hégemonikon* is the principle and the *pneuma* the agent. Therefore, as it is conceived by Galen, movement in the living is the effect of a power that is immanent to the organism. The animal, one could say, *is-brought-to-act* itself by itself in its own milieu⁷⁵ — no doubt depending on the milieu as movement is paired with sensation — but in no way is it acted [on] or brought to action from the outside. The animal, during muscular movements, *soars/rushes forth/sets off*⁷⁶ from its center onward. Through Galen, the notion of *impetus*, Latin equivalent of the Hippocratic *ἐνσπῶν* and the stoic *όρμη* will be the foundation for all the theories of muscular movement until Descartes. The destruction of this linkage, of a vitalist orientation, between animal movement, and impetus/momentum/impulse⁷⁷ of an internal force, will be the first objective pursued by Descartes in matters of physiology. That is why the doctrines that he will attack must be recovered as closely from their original inspiration as possible. Yet we see the makings, in Galen, in the doctrine of muscular movement, of a theory of the union of the soul and the body which Descartes is bound to encounter. Galen, we've seen, brings back involuntary muscular movement to a voluntary unconscious of itself. In animal movement, it is *always* the soul that moves the body. In chapter VI of *De foetuum formatione libellus*,⁷⁸ is lead to deal with the motion of the body by the soul. The difficulty is to explain how the intelligent soul can move the body based on knowledge⁷⁸ about the organs and their functions, which is similar to presupposing in the soul of the first come an anatomical and physiological knowledge far superior to the best of anatomists, who barely know, based on dissections, the proper function of each of the muscles. This argument will traverse the centuries and we will find it again, unchanged, in Malebranche supported by the thesis that only the Creator of bodies can and knows how to be its Motor (*Entretiens sur la métaphysique*, VII, p. 13). The other difficulty is to know if one needs to distinguish on one hand, a Soul forming and organizing⁷⁹ the body, conforming to a finality which does not admit

→ Galen

(1) *Geschichte der biologischen Theorien in der Neuzeit*, I, 2nd ed., Leipzig, 1913, p. 3.

⁷⁴trans. note : dynamiste.

⁷⁵trans. note : an early complicated passage for the translator, where C. - as philosophers during important occasions do - bends grammar in order to communicate complex ideas that would otherwise be restricted by the usual limits of language (a conscious transgression introduced by the warning / apology "one could say", doubled by the use of italics). An alternative translation sounds nice but is less accurate or faithful : "by itself of its own in its own milieu". (L'animal, pourrait-on dire, s'agit lui-même de lui-même dans son milieu ...)

⁷⁶trans. note : s'élance.

⁷⁷trans. note : élan

⁷⁸trans. note : connaissances.

⁷⁹trans. note : formatrice ... organisatrice.

→ trans. note: For another ¹⁷ discussion of this term see note 3 of the appendix.

lacks/gaps/shortcomings⁸⁰, and on the other hand, the soul which moves a body formed. Galen thinks we must admit the identity of the soul, organizing principle of the body, and of the soul principle of voluntary movement, in brief of the artist soul and of the reasonable soul. The soul that moves⁸¹ is thus a soul that knows its body in entirety / integrally like an instrument it has made, but does not reflect its knowledge. "I thus admit being able to affirm, as far as the formative/forming⁸² cause of animals is concerned, this only as the art and the wisdom in them is of the highest degree, as well as, the body having been fully / integrally formed, it is regulated during all of life by three principles of movement, from the brain on by means of the nerves and the muscles, from the heart through the arteries, from the liver through the veins (1)."

Remains now to know if the soul moves the body directly or through some instrument and intermediary. This is the place where we resume the essential of Galen's ideas on the nature and the functions of *πνεῦμα*, given that under the name of spirit (*spiritus*) animal or psychic we find these Galenic theories at the bottom or in the background of all the theories which, until the XIXth century, have delegated to animal spirits the responsibility of the neuro-muscular mechanism of contraction and of movement. We need not enter the details of the discussions which have opposed historians on the issue of knowing what the respective part is, of Hippocrates, of Aristotle and the doctors of the Sicilian school, in the formation of the stoic doctrine of *πνεῦμα*. We think that Werner Jaeger has well established, especially, that if Aristotle may have, on this precise point, inspired the conceptions of Zeno, it is through the intermediary of Diocles of Carystus, whose life must be pushed back by about three quarters of a century compared to dates which had approximately been assigned to him by Wellmann (2). Being that it is in the doctrines of Galen that one must seek the source of the influence exercised by the theory of *pneuma* on doctors of the Middle Ages and the Renaissance, we do not need to go further back⁸³ than this source (3).

Galen admits the existence of a triple *pneuma* : psychic,

(1) *Opera omnia*, KÜHN, IV, p. 701.

(2) W. JAEGER, *Das Pneuma in Lykeion* (*Hermès*, t. XLVIII, 1913); *Diokles von Karystos*, Berlin, 1938.

(3) For everything concerning the stoic theory of *pneuma*, consult : 1° L. STEIN, *Die Psychologie der Stoa*, t. I, Berlin, 1886. Ist Part, chap. II : "Le ~~pneuma~~ originel"; IInd Part, chap. I to VII ; "Sur l'origine, la substance, les fonctions et le siège de l'âme" ; 2° E. BRÉHIER, *Chrysippe*, Paris, 1910, p. 122 sqq. and 163. — Good summary on the legacy⁸⁴ of the theory of *pneuma*, from Aristotle to the XVIIIth century, in one note (p. 430) of the Roustan & Schrecker edition of *La recherche de la vérité* of MALEBRANCHE (t. I and II, Boivin, 1938).

The original
pneuma

→ On the origin, the substance, the functions and the seat of the soul

⁸⁰trans. note : lacunes.

⁸¹trans. note : motrice.

⁸²trans. note : formatrice.

⁸³trans. note : remonter.

⁸⁴trans. note : fortune.

contained in the brain and the nerves ; vital, in the heart and the arteries ; physical, in the liver and the veins. The psychic pneuma results from the mix in the arteries of the base of the brain (1) and the cerebral ventricles, of air directly inhaled through the nostrils and of vital spirit — mix, in turn, in the left ventricle of the heart, of blood and of pulmonary air (2). The psychic pneuma is not the soul, the substance of which Galen makes no pronouncement on, but its first instrument (3). The soul uses it for sensory knowledge and involuntary movement (4). The brain is endowed with / capable of⁸⁵ a double movement ; of diastole through which it sucks [up]⁸⁶ air and the vital pneuma ; of systole through which it chases in the nerves the psychic pneuma.

As for the vehicles of psychic pneuma, the nerves, they are of two orders : soft nerves that link/connect⁸⁷ the brain to sensitive parts of the body, hard nerves that connect the mobile parts to the cerebellum⁸⁸ and the ~~bone marrow~~/spinal cord. The parts that are both mobile and sensitive (eyes, tongue) receive nerves of the one and the other sort (5).

On the detail of the mechanism of muscular contraction, Galen does not explain himself. He doesn't do microphysiology. We merely know that despite the distinction he makes between nerves and tendons, he assimilates nerves to strings/ropes⁸⁹. This takes us back to the distinction between soft and hard nerves, depending on whether they are sensitive or motor.

But there is one point of this muscular physiology which deserves to be kept in mind especially. It is the discovery by Galen of the tonic function of the muscle. Sherrington and Fulton have rightfully drawn attention to this point (6). In the *De motu musculorum*, I, 7-8, Galen makes the observation that muscles have movements of 4 sorts : contraction, extension, passive movement of abandonment, tonic maintaining of posture (τεταμένον μένουσιν) (7). It is to explain this last property that Galen uses the notion of tonic movements (τονικαὶ κινήσεις) (8).

(1) Galen calls this anatomical formation δικτυώδες πλέγμα, it's the famous *rete mirabile*, "the admirable retiform"⁹⁰ plexus" (A. PARÉ).

(2) GALEN, *De placitis H. et P.*, VII, 3 ; KÜHN, V, p. 606-10. — Cf. VERBECKE, *op. cit.*, p. 208-10.

(3) GALEN, *ibid.*

(4) *Ibid.* ; cf. also *De locis affectis*, III, 9 ; KÜHN, VIII, p. 174.

(5) *De usu partium*, VIII, 5 and IX, 14 ; KÜHN, III, p. 633-34 and 741.

(6) SHERRINGTON, Note on the history of the word tonus, in *Contributions to Medical and Biological Research dedicated to Sir William Osler*, New York, 1919, I, p. 261. — FULTON, *Muscular Contraction and the Reflex Control of Movement*, Baltimore, 1926, p. 5-7.

(7) *Op. omnia*, KÜHN, IV, p. 403.

(8) *Ibid.*, p. 400-401.

⁸⁵trans. note : doué.

⁸⁶trans. note : aspire.

⁸⁷trans. note : relient.

⁸⁸trans. note : cervelet

⁸⁹trans. note : cordes.

⁹⁰trans. note : rétifforme. Describes a net-like structure (from the Latin for net, *rete*).

We know now, especially since the works of Sherrington, what trait of genius it is, on the part of Galen, to have considered as a special case⁹¹ of motor activity the tonus of posture. Fabricius of Acquapendente and Borelli will take up again⁹² the views of Galen for their treatises on movement. But Descartes will totally ignore this notion or at least will never speak of it.

Yet⁹³ it seems to us that if Galen was able to have this intuition of tonus as a particular case of movement, even in the ignorance in which he was of the mechanism of reflex action, it was a function of the biological philosophy that was his and of which we have already noted the authentically dynamist character. Neither Sherrington, nor Fulton after him / in his following⁹⁴, to us appear to have been able to grasp, in the work of Galen, the relationship between *tonos* and *pneuma*. The *tonos* is the effect of the *pneuma*, which is translated experimentally for Galen in the flaccidity of the muscle whose nerve is sectioned. This is of stoic inspiration. The cosmic as well as organic *pneuma* ensures through its tension the cohesion of the living macrocosm as well as microcosm. In the animal, for example, sleep⁹⁵ is a relaxation⁹⁶ of the *tonos* in the *hégèmonikon* (1). The soul, through its incessant action, from the center to the periphery and reciprocally, is the instrument of the cohesion and of the tension of the body. The physiological notion of tonus thus has its origin in the stoic philosophy which conceives of the life of the soul and of the animation of the organism as an effort, a will that is permanent. The physiology of Galen incorporates this psychology and ethics in the theory of muscular contraction. Even the posture is a movement, [the state of] immobility is not an inaction. Physiology and morals coincide in the invention of the term and of the notion of muscular tonus (2).

*

* *

It is to Nicolo Leonicensus (1428-1529), doctor of Ferrara, that we owe the first Latin translation of Galen's treatise on muscular movement. Fulton thinks that this translation was done between 1509 and 1520. It was not published in Italy, but in London, in 1522, by a student of Leonicensus, Thomas Linacre. This translation is, in matters of the physiology of the muscle, the

(1) Diogenes LAERTIUS, *Lives and opinions of eminent philosophers*, book VII : *The Stoics*, in *fine*.

(2) On the relations between the *pneuma* and the *tonos* in⁹⁷ the Stoics, see STEIN, *op. cit.*, p. 30 sq., and VERBECK, *op. cit.*, p. 71 sq.

⁹¹trans. note : cas particulier.

⁹²trans. note : reprendront.

⁹³trans. note : Or.

⁹⁴trans. note : as sa suite.

⁹⁵trans. note : sommeil.

⁹⁶trans. note : détente.

⁹⁷trans. note : chez.

capital event of modern times. The second edition was published in Paris, in 1528, by Gunther von Andernach, master of Vesalius. In 1549, a reworked edition based on a new Greek manuscript, appeared in Lyon courtesy of Jacob Sylvius. In 1541, Jean Canappe had published a French translation of Galen's treatise, in Lyon, at Étienne Dolet. In 1562, Conrad Gesner published in Basel a Latin edition of the works of Galen (1). On the presentation, in the Latin translations, of the physiology of Galen and on the introduction of Galenism at the University of Paris, one must consult the beautiful book by Ch. Singer and S. Rabin : *A prelude to modern science (Discussion of the history, sources and circumstances of the Tabulae anatomicae sex of Vesalius)* (2).

It is well known that Leonardo da Vinci (1452-1519) and Andreas Vesalius (1514-1562) were interested in the structure and action of muscles, that the first has left in his papers geometric schema of muscular contraction which announce the mechanical studies of Borelli, that the second in his *De humani corporis fabrica* (1543) relates the experiences of the ligature of the nerves and subsequent atony of the muscles. Vesalius defends against the Aristotelians the Galenic theory of the cerebral origins of nerves, the propagation along the nerves of the animal spirit ; but he doesn't admit that the nerves are hollow⁹⁸, he sees them as cylindrical and without appreciable cavity ; like Galen, he distinguishes between hard and soft.

However, it is the work⁹⁹ of Fabricius of Acquapendente (1537-1617), the master of the illustrious Harvey, that is the first specialized work by a modern author dedicated to the activity of the muscle (3) : *De musculis* : I. *De musculi fabrica* ; II. *De musculi actione* ; III. *De musculi utilitatibus* (1614). We will keep in mind here especially the Second Part. F. of Acquapendente only deals with movements that are of central origin, voluntary in humans, spontaneous in animals. He admits the whole of Galenic physiology, but in the metaphysical and logical framework⁵ of Aristotelianism. In matters of movement, the brain is the *primum movens* (*quod tantum movet et non movetur*) ; the bones are moved without moving ; the muscles are both moved and motor ; the nerves are the canals which conduct to the muscles the animal spirits emanating from the brain as from their source. The experiences of ligature of the nerves are invoked, just as by Galen, supported by the theory of the influx of spirits in the nerves. Aristotle and Galen are

(1) Cf. FULTON, *op. cit.*, p. 8-9.

(2) University Press, Cambridge, 1946 ; see particularly chap. II, 2, and chap. IV.

(3) FULTON, *op. cit.*, p. 12.

⁹⁸trans. note : creux

⁹⁹trans. note : ouvrage.

adds nothing (altern.)

in agreement when it comes to affirming that the motor power flows from the nerves to the muscles. Aristotle makes movement start from the heart. He is mistaken, at fault for not having experimented through dissection and vivisection. All of this, we see, is pure Galen and doesn't add anything new⁽¹⁾.

But what is more interesting, is the attempt made to give an explanatory theory of the mechanism of muscular contraction under the effect of nervous influx. The propagation of nervous influx inside the nerves is assimilated to the action of the magnet or the ~~naval~~ torpedo¹⁰⁰. Just as the magnet attracts the iron or the torpedo numbs/dulls¹⁰¹ the hand that has touched it, just so acts on the muscle the motor power ~~transported/conveyed~~¹⁰² by the nerves (2). The diffusion to the whole muscle of this motor power does not demand¹⁰³ that the nerve sends ramifications to the whole of the muscle. And there appears, for the first time in the modern period, a capital idea, according to us, in the formation of the notion of reflex movement, the assimilation of the nervous influx to light. The motor power, says Fabricius of Acquapendente, spreads¹⁰⁴ inside the muscle like light. Appropriately/Duly/As required¹⁰⁵, the authority of Galen is invoked and also his experience. *Nam et Galenus hanc sane vim lumini comparat quod momento temporis in totum medium diffunditur, et corpora quae contingit alterat et illuminat...* *Pari ratione in totum musculum per nervos transmittitur et more luminis irradiatur* (3). As for ~~experience~~ it is, as is so often the case during that epoch, a story, a narrative¹⁰⁶, where there is mention of facts properly fantastical¹⁰⁷, of animal cadavers from which light is supposed to have emanated (4). Yet this assimilation of the animal spirits to light : we won't find any trace of it in Descartes, but on the contrary we will find in Willis that it takes on an importance of which we need not regret it seems, due to¹⁰⁸ theoretical results, that it should be so disproportionate from its experimental substrate. The explanation of muscular contraction by a phenomenon of attraction analogous to that of the magnetized iron¹⁰⁹ has the advantage further of enabling Fabricius of Acquapendente to maintain his physiological theories within the scholastic frames of Aristotelian dynamics. In sum, the contracted muscle is attracted towards the brain

experiment

(1) *Opera omnia*, Leiden, 1738, m. 398-400.

(2) *Ibid.*, p. 404. It is only in 1755 that Musschenbroek assimilated the physiological effects produced by contact with the torpedo with the discharge of the bottle of Leiden. The decisive experiments establishing the fact are owed to the English physician Walsh, in 1772. Cf. MATTEUCCI, *Traité des phénomènes électro-physiologiques des animaux*, 1844, chap. XII.

(3) *Ibid.*, p. 404.

(4) *Ibid.*, p. 405.

¹⁰⁰trans. note : torpille marine.

¹⁰¹trans. note : engourdit.

¹⁰²trans. note : véhiculé

¹⁰³trans. note : exige.

¹⁰⁴trans. note : se répand.

¹⁰⁵trans. note : Comme il se doit.

¹⁰⁶trans. note : une histoire, un récit ..

¹⁰⁷trans. note : fantastiques.

¹⁰⁸trans. note : en raison.

¹⁰⁹trans. note : fer aimanté

and from it¹¹⁰. Just as the immobile magnet¹¹¹ mobilizes the iron, the immobile brain mobilizes the arms or the legs by the means of the nerves. Thus movement depends always/still¹¹² on an immobile motor principle (1).

We have no testimony or proof that Descartes read the *De musculis* of F. of Acquapendente. But we know with certainty that he read (2) by the same author the *De ovi et pulli formatione* (1621) and the *De foetu formato* (1600). It is very unlikely that the theories of the famous doctor on muscular movement would have been entirely ignored by him / unknown to him.

*
* *

On the other hand/Though¹¹³, it's certain that Descartes had read Fernel (1497-1558) or at least that he knew his physiological and medical theories well; in a letter to Plempius, of the 15th February of 1638, he cites him as an authority (3). Mr. Gilson has shown that the theories of Fernel on the movement of the heart and the spirits are those that were taught to Descartes by the Jesuits of La Flèche (4).

Fernel develops in his *Physiology* the theories of Galen (5). He admits the distinction of three faculties (the famed/famous "vital tripod") : natural faculty, seated in the liver and exercising itself through the vital spirits along the veins ; vital faculty, seated in the heart and exercising itself through the vital spirits along the arteries ; animal faculty, seated in the brain and exercising itself through the animal spirits along the nerves. The natural faculty rules the functions of nutrition and does not command of movements. The vital faculty rules the so called voluntary movement, that is to say capable of being arbitrarily begun or suspended, and whose normal effect is tiredness¹¹⁴. As for the vital faculty, it governs/rules/regulates¹¹⁵ the non voluntary movements, non subjected to tiredness, and for these two reasons constant. Correlated, the heart, perpetually moved, is not a muscle (*Physiology*, book I, chap. VIII). Thus Fernel

(1) *Ibid.*, p. 408.

(2) See index of the works cited by DESCARTES, in *Œuvres*, ed. Adam-Tannery, *Index general*, p. 64-65.

(3) *Ut auctoritatem etiam auctoritate refellam* Ad.-T., I, p. 533.

(4) Descartes, Harvey et la scolastique, in *Etudes de philosophie médiévale*, Strasbourg, 1921 ; reproduced in *Etudes sur le rôle de la pensée médiévale dans la formation du système cartésien*, Paris, 1930.

(5) The great medical treatise of FERNEL, *De naturali parte medicinae* appeared¹¹⁶ in 1542 in Paris. It was edited again / reissued¹¹⁷ in 1554 under the title *Physiologia*.

¹¹⁰trans. note : à partir de lui.

¹¹¹trans. note : l'aimant.

¹¹²trans. note : toujours. (≠ encore)

¹¹³trans. note : Par contre.

¹¹⁴trans. note : la fatigue

¹¹⁵trans. note : régit.

¹¹⁶trans. note : parut.

¹¹⁷trans. note : réédité

still accepts the equation of muscle and organ of the will (1). The function of the heart in the general economy of the organism is double : to produce heat and movement. Unlike¹¹⁸ Aristotle, Fernel does not believe that the ebullition of blood is the cause of cardiac pulsations. He thinks that the heart is endowed with¹¹⁹ ~~with~~ a pulsar faculty¹²⁰ (*vis pulsifica*), extending also/equally¹²¹ to the arteries and explaining their pulse. This faculty is thus distinct from the vital faculty, cause of the heat of the blood and the animal spirits. In spite of this distinction of the three faculties, the soul is simple and the spirits are the obligated¹²² intermediaries between the body and it (2).

We see that, on the whole, Fernel chooses consciously Galen against Aristotle. And nonetheless his theory of motricity is original enough¹²³ on one precise point to be worthy of a mention. Like Galen, he holds that the organs and nerves of movement are different from those of sensibility¹²⁴, and he finds support for this¹²⁵ in the acts of dissociation brought on by maladies : in the case of paralysis movement is removed but sensibility/sensitivity¹²⁶ persists, in the case of folly sensibility¹²⁷ is abolished and movement brought to its paroxysm. Like Aristotle, he holds the impulse¹²⁸ of appetite for principle of movement. But different from Galen and Aristotle, he admits a relative independence of the locomotive faculty (3). While the two ancient authors are greatly pained / feel the greatest difficulty¹²⁹ when it comes to accounting for automatic movement, Fernel, invoking involuntary and unintentional movement, for example the movement of the [eye]lids¹³⁰, respiration during sleep, seeks to diminish the part and the role of the soul and that of deliberation in the explanation of movement. That he only succeeds verbally is undeniable, at least he has the merit of having had the idea, besides¹³¹ perhaps after / based on Galen, that movement is all the more automatic and autonomous that it is more closely guided by the principle of pleasure and of pain (4).

*
* *

It is not exact that one must, as is often gladly/freely¹³² stated, wait until Harvey for the heart to be identified with a muscle.

(1) SHERRINGTON, *The Endeavour of Jean Fernel*, Cambridge, 1946, p. 83.

(2) *Ibid.*, p. 79.

(3) *Physiology*, ~~liv.~~ V, chap. IX and ~~liv.~~ VI, ch. XVIII. Cf. SHERRINGTON, *op. cit.*, p. 82.

(4) Cf. L. FIGARD, *Un médecin philosophe au XVIe siècle. Etude sur la psychologie de Jean Fernel*, Paris, 1903, p. 270-275.

¹¹⁸trans. note : A la difference

¹¹⁹trans. note : doué.

¹²⁰trans. note : pulsifique.

¹²¹trans. note : également.

¹²²trans. note : obligés.

¹²³trans. note : assez ...

¹²⁴trans. note : sensibilité.

¹²⁵trans. note : s'appuie.

¹²⁶trans. note : sensibilité.

¹²⁷trans. note : sensibilité.

¹²⁸trans. note : impulsion.

¹²⁹trans. note : peine.

¹³⁰trans. note : paupière.

¹³¹trans. note : d'ailleurs.

¹³²trans. note : volontiers

Hippocrates (1), among the ancients, and Leonardo da Vinci (2), among the Moderns had done it. However, none had known, before Harvey, [how] to found this assimilation correctly on [the basis of] a methodological exploration of the movements of the two organs leading to recognizing the systole as the active phase of the heart's function (3). But Harvey retained if not the terms then the notion of *vis pulsifica*. And that is what explains, as Mr. Gilson has [so] well shown (4), that Descartes admitted the circulation of blood by rejecting the theory of Harvey regarding the movement of the heart. Descartes admitted with the scholastics that the heart was the seat/site of a heat superior to that of any other part of the organism, but could not admit the existence, supposed¹³³ by Fernel, of a pulsar cardiac force. From this comes / Therefrom his opposition to Harvey and his loan from Aristotle of the theory of cardiac fire. He thought he was thus explaining at once the movement of the heart, outside of any appeal to an occult quality, and its singular temperature. It's in the *Discourse on the method* [*Discours de la méthode*] (1637) that Descartes separates [himself] from Harvey, whom he had not read when he composed the *Treatise of Man* [*Traité de l'homme*] (1632).

*

* *

At the end of this rapid historical inventory, we can count¹³⁴ the notions that Descartes will only need to keep, revised or not, from his readings or the teaching¹³⁵ [he] received, at the moment when he will attempt to reduce muscular movements to pure mechanical effects. From the Galenic tradition he holds the distinction of voluntary movement and of natural movement, the notion of the muscle as the organ of movement, the relationship of the nerves and the muscles, the encephalic origin of the nerves, the distinction of the sensitive and motor ways¹³⁶, the distinction of the animal spirits

Hippocratic School²

(1) The opinion is related in the treatise *Du coeur* of the "Collection hippocratique". See on this subject *Observation et expérience chez les médecins* of the "Collection hippocratique" by L. BOURGEY, Paris, 1953, p. 137.

(2) *Les carnets de Léonard de Vinci*, trans. SERVICEN, Paris, 1942 : "The heart in itself is not the principle of life : it is a vessel¹³⁷ formed by thick muscles, vivified and nourished by the arteries and the veins, just as the other muscles" (I, p. 141). "The heart is an essential muscle from the perspective of power and much more powerful than the others."

(3) ... *ipsiusque [cordis] motum esse qualem musculorum dum contractio fit secundum ductum partium nervosarum et fibrarum : musculi enim, cum moventur et in actu sunt, vigorantur, tenduntur, ex mollibus durifiunt, attolluntur, incrassantur, et similiter cor* (*Exercitatio anatomica de motu cordis et sanguinis in animalibus*, 1628, chap. II). Cf. in the French translation of Charles LAUBRY (Paris, Doin, 1950), p. 154.

(4) *Descartes, Harvey et la scolastique*, in *op. cit.*

(5) See further below chap. II, p. 32, n. 5.

¹³³trans. note : supposé.

¹³⁴trans. note : dénombrer

¹³⁵trans. note : l'enseignement.

¹³⁶trans. note : voies.

¹³⁷trans. note : vaisseau.

and the vital spirits. To which is added, under the influence of Fernel (1), the notion of a certain independence of the locomotive function with respect to the will. From the discovery of Harvey, Descartes retains only the circulation. But when he attributes to the heart an internal heat, source of the initial impulse of all movements of the muscles, it is to Aristotle that he goes back [to], beyond Galen.

(1) On Descartes and Fernel, see SHERRINGTON, *op. cit.*, IInd Part : *The earliest "Physiology"* and especially p. 73-89.

CHAPTER II

THE CARTESIAN THEORY OF INVOLUNTARY MOVEMENT

What disposes us to believe, thinks Descartes, that the soul is the principle of all the movements of the body is, joined with our experience lived of voluntary movement, our child-like ignorance of anatomy and mechanics (1). It is therefore suitable⁷ for Descartes to rectify, in physiology just as in any other matter, one of the innumerable prejudices of our childhood. Therefore the clarity of his reiterated affirmation, that, relative to the determinations of the will, the independence of the human body's movements is possible and effectively frequent. Well understood/Of course⁸, the phenomena invoked by Descartes are those which have, for the longest already, raised and kept/captured⁹ the attention of doctors, namely the pathological contractions of organs injured or separated, however, more readily, in the normal human, the forced dependence of movements upon other movements or on certain sensory stimuli/excitement¹⁰. Aristotle and Galen had posed the problem of the coordination and the integration of the motor and mobile segments of the animal body, by becoming interested in the movements of animals divided/split¹¹. For multiple centuries the solution have been provided by the doctrine of ~~trans. not~~ ^(the) sympathies, that is to say immaterial connections between parts of a same organism (2). We will talk at greater length about the doctrine of the

(1) La description du corps humain, *Œuvres*, ed. Adam-Tannery, XI, p. 224.

(2) LITTRÉ, in his *Dictionnaire*, gives, in 1878, the following definition of the word sympathy : "Term from physiology. Existing relation between two or many organs more or less distant from one another and which makes it so that one of them participates to the sensations sensed or the actions executed by the other." Let's add that, according to the doctrine of sympathies, an immaterial connection is given not only between the various parts of the body, but also/equally¹² between similar organs of different organisms, which justified therapeutics based on organs. — Let us note that DESCARTES uses, at least twice, to our knowledge, this notion of sympathy. Cf. *Primae cogitationes circa generationem animalium* A.-T., XI, p. 515 and p. 518.

next
page
(or leave)
be.

⁷trans. note : convient.

⁸trans. note : bien entendu.

⁹trans. note : suscité et retenu.

¹⁰trans. note : excitations

¹¹trans. note : divisés.

¹²trans. note : également.

sympathies in our chapter 5. We only say one word about it here, with the aim of stressing¹³ that Descartes is the first to substitute to the confused notion of sympathy, the notions, near¹⁴ mathematically clear, of disposition of organs and of mechanism and who confers to the distinction of animal movement and psychic animation a decisive reach¹⁵, by using it in the explanation of human behavior. We cite in full two capital texts, in their chronological order.

"... It is mightily remarkable a thing that not a movement can be made, either in the bodies of beasts, or even in our own, if these bodies do not have in themselves all the organs and instruments by means of which these same movements could be accomplished inside a machine ; such that even in ourselves, it is not the spirit or the soul which moves immediately the exterior members, but only it can determine the course of this liquor mightily subtle ~~that can~~¹⁶ call animal spirits, which, following continuously from the heart through the brain in the muscles, is the case of all the movements of our members, and often can cause many different [ones] as easily the ones as the others. And even it does not determine always, because among the movements that are made inside of us, there are multiple [ones] that do not depend at all on the spirit, such are the beatings of the heart, the digestion of meats, the nutrition, the respiration of those who sleep, and even in those who are awake, walking, singing, and other similar actions, when they occur without that the spirit should think them. And when those who fall from high up show their hands first to save their heads, it is not all through the council of their spirit, but only that their senses, being touched by the present danger, cause some change in their brain which determines the spirits of animals to move from there to the nerves, in such fashion that is required to produce¹⁷ this movement just as in a machine and without that the spirit could prevent them. (1)."

16

"We can also see that, when some parts of our bodies are injured, for example when a nerve is hit¹⁷, this makes it so that they do not obey to our will, as had been their custom, and even that often they have movements of convulsion, that are contrary to it. [Fact] Which shows that the soul

18

(1) *Réponses aux IVe objections*, A.-T., IX, p. 178 ; BRIDOUX, 2nd ed., p. 447-48.

¹³trans. note : en vue de.

¹⁴trans. note : quasi, in the original.

¹⁵trans. note : portée.

¹⁶trans. note : "... C'est une chose fort remarquable qu'aucun mouvement ne se peut faire (...) l'esprit le puisse empêcher." (D. expresses himself in a way that does not correspond much to modern/current French, which we attempt to get across.)

¹⁷trans. note : piqué.

¹⁸trans. note : "Nous pouvons voir aussi que, lorsque quelques parties de notre corps sont offensées (...) bien que ce soit l'âme qui les détermine."

(cf from is
gram. incorp. +)

can not excite any movement in our bodies, if it were not for that all corporal organs, which are required for this movement, are well disposed ; but that, on the whole contrary, when the body has all its organs well disposed for some movement, it does not need the soul to produce it ; and that, as a consequence, all the movements that we experience not to depend at all ~~from~~ our thoughts, cannot be attributed to the soul, but to the sole disposition of the organs ; and that even the movements, which we call voluntary, proceed principally from this disposition of the organs, since they cannot be excited/provoked without it, whichever will we may have for them, although the soul may determine them (1)."

It is not doubtful that, among the phenomena of muscular automatism invoked by Descartes based on his refusal to attribute to the soul the responsibility of all the movements of the human body, many are authentic reflexes, in the sense given to this term by contemporary physiologists. Such are the reflexes of swallowing (2), of flexion of the leg (3) or of the arm (4) in response to a strong thermal stimuli/excitement of the foot or the hand, of pupillary accommodation (5), of occlusion of the eyelids (6), of cough (7), of sneezing (8), of

(1) *Description du corps humain*, A.-T., XI, p. 225. We know that this opusculum was published in 1664, by CLERSELIER, in the appendix to *Traité de l'homme*. It is likely/plausible/probable that STENO has read it, for living in Paris in 1664-65, he cites the *Traité de l'homme* in his *Discours sur l'anatomie du cerveau* of 1665. In any case in his *Elementorum myologiae specimen* (1667) he claims/asserts/declares, as Descartes here, that if all voluntary movement is done through the muscles, all movement done through the muscles is not necessarily voluntary (*Opera Philosophica*, Copenhagen, 1910 t. II, p. 101).

(2) *Traité de l'homme*, A.-T., XI, p. 140 ; BRIDOUX, p. 822.

(3) *Ibid.*, A.-T., XI, p. 141-42 and p. 191-93 ; BRIDOUX, p. 823 and 865. In these two examples, talk is of nonceptive reflexes, according to current terminology. The figures that represent the mechanism supposed by Descartes (fig. 7 and 37 of the boards reproduced at the end of t. XI of the Adam-Tannery edition, and in BRIDOUX on p. 823 and 865) are not by the hand of Descartes. Nothing permits us to attribute them either to Gerard van Gutschoven or to Louis de la Forge of whom Clerselier has put to profit, not without casualness, the involuntary collaboration (cf. CLERSELIER's preface to the 1664 edition of *Traité de l'homme*, A.-T., XI, p. xiii-xiv). They are found in pages 58 and 160 of the edition of 1677 (Amsterdam, Elzevir), *Tractatus de homine et de formatione foetus quorum prior notis perpetuis Ludovici de La Forge M. D. illustratur*, which we have consulted at the library of the Ecole normale supérieure.

(4) *Ibid.*

(5) *Ibid.*, A.-T., XI, p. 156-57 ; BRIDOUX, p. 834. — *Traité des passions*, art. 44.

(6) *Traité des passions*, art. 13. The end of this article, where the example is described ("Should someone promptly near their hand against our eyes..."¹⁹), has often been reproduced and notably by the Pr Léon BINET, in the collection²⁰ of articles *Médecins, Biologistes et Chirurgiens* (S. E. G. F. P., Paris, 1954), p. 35.

(7) *Traité de l'homme*, A.-T., XI, p. 141 ; BRIDOUX, p. 822.

(8) *Ibid.*

¹⁹trans. note : "Si quelqu'un avance promptement sa main contre nos yeux..."

²⁰trans. note : recueil.

yawning (1), of excretion (2). But from the fact that Descartes, when he proposes a general theory of involuntary movement, puts it into relation, like so many others before him, with phenomena today called reflexes and explained as such, should one conclude that he has [earned] his place in the series of naturalists and doctors who have contributed to the denomination and to the definition of the *concept* of reflex? Here is, according to us, the epistemological and historical problem that we must reserve, until the careful/meticulous and critical study of Cartesian anatomy and physiology makes it possible to decide if Descartes could or not anticipate, be it confusedly, the essence itself of the concept.

One wouldn't know to insist too much on the fact that the assimilation of physiological functions to pure and simple mechanical phenomena leads Descartes to reduce to contact, to choc, to push and to traction (3), all the relations that the parts of the organism have between each other. It is in the meeting of this affirmation of principle and the anatomical observations of which he believes he can be content that we should see the last reason²¹ of the systematic conception that Descartes has²² of animal movement, conception whose expose will lead us to examine the nature and the course of animal spirits, the structure and the functions of the heart, the nerve and the muscle.

The animal spirits are the most subtle part of the blood, [a] fluid body moved very rapidly through[out] the organism ; it is they which, flowing incessantly from the arteries to the nerves and the muscles through the brain, move the entire corporal machine (4). The composition of the spirits is that of the blood, as variable as can be that of blood (5). Their physical nature is that of the wind (6) or the flame (7). They are blood which has lost its form (8). Not doubt therefore, the animal

(1) *Ibid.*

(2) *Ibid.*

(3) *Caeterum non admitto varia motuum genera, sed solum localem, qui corporum omnium, tum animatorum, tum inanimatorum, communis est. Letter to Bullendijck, 1643, A.-T., IV, p. 65.* We know that by local movement one must understand the transport of a body from the neighborhood of those that touch it immediately to the neighborhood of some others. See *Les principes de la philosophie*, I, art. 26.

(4) *Letter to Bullendijck, 1643, A.-T., IV, p. 65.*

(5) *Traité de l'homme*, A.-T., XI, p. 166 sq. [¶]Lastly, all that can cause any change in the blood can also cause it in the spirits" (*ibid.*, p. 169). BRIDOUX, p. 842-44.

(6) *Ibid.*, XI, p. 129. — *Traité des passions*, art. 8. — *Discours de la méthode*, Vth Part. — *Description du corps humain*, A.-T., XI, p. 227.

(7) *Ibid.*

(8) *Traité de l'homme*, A.-T., XI, p. 130 ; BRIDOUX, p. 814.

²¹trans. note : raison dernière.

²²trans. note : se fait.

spirits "are only bodies" (1), they are not the cause of the movement of the members be it only because²³ their own movement is done "according to the laws of nature" (2) outside of any power or own inclination. If Descartes compares them to a flame it is only to give an idea of their tenuity and of the speed of their movement (3).

It is in the small branches of the carotids that the separation and sifting of animal spirits happens/takes place/is carried out. They penetrate inside the brain by two ways, by the arteries inserted in the pineal gland (5), and by the arteries whose network line²⁴ the concavities of the brain (6).

The origin of the perpetual movement of spirits is the same as that of blood, it is the action of the heart (7). Descartes compares the heart and the arteries to the bellows²⁵ of an organ, pushing the spirits to the brain as in a windtrunk²⁶, from which they are distributed, through pores, in the nerves like inside pipes (8). One must thus imagine²⁷ the brain, swollen with spirits like a balloon, or like a sail²⁸ (9).

The distribution of the spirits, at the exit of the brain, according to the various possible directions of their movements, depends on multiple causes. First it is the action of the objects that move the senses, which is to say the stimuli/excitement²⁹, which Descartes compares to the fingers of the organist pressing on the keys of the keyboard (10). Then, it is the position of the pineal gland in the concavity of the brain, and the modifications of their external surface, position and modifications of which Descartes at length studies the dependence with respect / in relation to the will, to the memory, to the imagination, and to the common sense (11). Finally, it is the instincts, because the exterior movements, which Descartes differentiates³⁰ expressly from

(1) *Traité des passions*, art. 10.

(2) *Traité de l'homme*, A.-T., XI, p. 137 ; BRIDOUX, p. 820.

(3) *Traité des passions*, art. 10. One passage of the *Primae cogitationes circa generationem animalium* could confirm, if there is a need, the materiality of the spirits : *Vis enim gravitatis est etiam commotio partium materiae corporeae, ut sunt spiritus animales*, A.-T., XI, p. 519.

(4) *Letter to the marquis of Newcastle*, April 1645, A.-T., IV, p. 191 ; BRIDOUX, p. 1181. *Letter to Mersenne*, December 24th 1640, A.-T., III, p. 264 ; BRIDOUX, p. 1103.

(5) *Traité de l'homme*, A.-T., XI, p. 129, 170, 172 and 173, BRIDOUX, p. 813, 844 and 847.

(6) *Ibid.*, A.-T., XI, p. 172 ; BRIDOUX, p. 847.

(7) *Traité des passions*, art. 8.

(8) *Traité de l'homme*, A.-T., XI, p. 165, BRIDOUX, p. 841.

(9) *Ibid.*, A.-T., XI, p. 173 ; BRIDOUX, p. 847. — *Letter to the marquis of Newcastle*, April 1645, A.-T., IV, p. 192 ; BRIDOUX, p. 1181.

(10) *Traité de l'homme*, A.-T., XI, p. 165, BRIDOUX, p. 841-42.

(11) *Ibid.*, A.-T., XI, p. 173-190 ; BRIDOUX, p. 847-864.

²³trans. note : que parce que.

²⁴trans. note : tapisse.

²⁵trans. note : soufflets.

²⁶trans. note : porte-vents.

²⁷trans. note : se représenter

²⁸trans. note : voile.

²⁹trans. note : excitations.

³⁰trans. note : distingue

italics

interior movements, that is to say the passions (1), are divided into movements of expression (laughing or crying for example), simply occasional, and into movements of adaptation, that is to say that they "serve to pursue things desirable or to avoid those that are harmful/detrimental" (2) which is to follow "the instinct of our nature" (3). This subordination of physiological mechanism to what one must well call a biological finality is not a Cartesian lapsus / lapse. We find it elsewhere than in the *Treatise of Man*. In *Primae cogitationes circa generationem animalium*, Descartes invokes the *commoda* and *incommoda naturae* as principles of the different directions of animal movement of which the animal spirits assure the mechanism (4). And let's not forget the *VIth Meditation*, to which Mr. Gueroult has recently restituted the full and striking meaning. To sum up, Descartes distinguishes three sorts of conditions in the course of animal spirits : exterior and contingent (the sensory stimuli/excitement), acquired and individual (the memory), natural and specific (instincts). There is here, let's admit it, a sense of - very remarkable - biological phenomenon of interaction between organism and milieu.

The continuity in the course of spirits is, we have seen it, under the dependency of the incessant circulation of blood, of which Descartes, after Harvey if not based on Harvey³¹, admits the reality (5). The continuity of the first movement expresses and imitates the regularity of the second, even in the immobile organism (6). In the organism like in the world [the] movement is constant and circular. But, differing from Harvey, Descartes does not admit that the initial motor

(1) *Ibid.*, A.-T., XI, p. 193 ; BRIDOUX, p. 867.

(2) *Ibid.*

(3) *Ibid.*, A.-T., XI, p. 193 ; BRIDOUX, p. 866.

(4) A.-T., XI, p. 519.

(5) DESCARTES writes in 1631 in the *Treatise of Man* : "The movement of blood in the body is but a perpetual circulation" (A.-T., XI, p. 127). And he confides to Mersenne (November or December 1632) : "I have seen the book *De motu cordis* of which you had spoken to me once / in the past and have found myself to be a bit different from his opinion, although I have only seen it after having completed / finished writing on this matter" (A.-T., I, p. 263). Harvey had published his book in 1628, but he taught the circulation since 1619. Descartes had thus rallied with Harvey on the faith of relations, one of whom Mersenne at least, before having read directly the full expose of the theory in the original work. On this question, see the opusculum of Dr HERPIN, *La querelle de la découverte de la circulation* (J.-B. Baillière, Paris, 1943), whose merit is clarity, but whose disadvantage / downside is the absence of references. That is why we remind here of the letter of Descartes to Plempius, February 15th 1638, A.-T., I, p. 521-534.

(6) *Ad motus animalium, oportet notare spiritus animales semper aequè celeriter moveri, quamvis nullos excitent motus in corpore* (*Primae cogitationes circa generationem animalium*, A.-T., XI, p. 518). "Never do they (the spirits) stop for a moment in one place" (*Traité de l'homme*, A.-T., XI, p. 171 ; BRIDOUX, p. 846.)

³¹trans. note : après ... sinon d'après.

of circulation is the contraction of the cardiac muscle. According to him, the movement of the heart is not a muscular movement. If the action of the heart is "the great spring" on which depends ultimately³² the movement of the muscle, it resembles it in no way, as it is not a move but a heat (1). The heart is a fireplace³³, the home / seat of a continuous fire "which is of no other nature than all the fires that are in the inanimate bodies" (2). It is the presence inside of it of this "fire without light" that makes the heart an organ without analogue, anatomically and physiologically, in the rest of the body. Undoubtedly, Descartes says that the heart is flesh, but this term is very vague with him ; he talks about the flesh of the heart (3) as he talks of the flesh of the lung (4) and the flesh of the muscles (5). Provided³⁴ he does use sometimes the term of tissue (6) Descartes does not speak as a histologist.

It is through dilation, vaporisation, and subtilization³⁵ of the blood in the right cavity of the heart that the singular heat of this organ becomes unique source of the general movement of the organism. The blood is projected through compression in the pulmonary artery ; in the same fashion, returned to the left heart through the pulmonary veins, it is chased in the aorta. Then this is when the animal spirits rise/climb/head directly to the brain owing first to the fact that the carotids are, of all the arteries, the ones which come from the heart most in a straight line (7), and secondly the fact that the spirits, being the most subtle parts of the blood, the most vivid, the strongest, are the ones which force the narrow passage towards which all the parts of the blood, chased by the heart, tend because of the laws of inertia and of rectilinear movement (8).

Put briefly, while, according to Harvey, the heart is a muscle whose

(1) *Description du corps humain*, A.-T., XI, p. 226.

(2) *Traité de l'homme*, A.-T., XI, p. 202 ; cf. also *ibid.*, p. 123 and *Discours de la méthode*, Vth Part.

(3) *Traité de l'homme*, A.-T., XI, p. 123 ; BRIDOUX, p. 809.

(4) *Ibid.*

(5) *Description du corps humain*, A.-T., XI, p. 273. The flesh seems to be for Descartes a sort of plastic element of the heart, of the lung and of the muscle. We do not find in him the same precision as in Fabricius of ACQUAPENDENTE who, in the *De musculi fabrica* (1614), decomposes the muscle into flesh, tendon, vein, artery, nerve and membrane (*Opera omnia*³⁶, Leiden, 1738, p. 396).

(6) *Traité de l'homme*, A.-T., XI, p. 170 ; BRIDOUX, p. 854. "All [of] the brain is nothing else but tissue..." Let us add, to be complete on this point, that Descartes admits the unity of the fibrillary composition of all the living, animals and plants (*ibid.*, A.-T., XI, p. 201 ; BRIDOUX, p. 872). It is the fibrillar theory that Haller, in the following century, should make famous. Cf. our *Connaissances de la vie*, Appendix I, p. 213.

(7) *Ibid.*, XI, p. 128 ; BRIDOUX, p. 812. *Letter to Mersenne*, December 24th 1640, A.-T., III, p. 264 ; BRIDOUX, p. 1104. *Traité des passions*, art. 10.

(8) *Ibid.*

³²trans. note : en fin de compte.

³³trans. note : foyer.

³⁴trans. note : Encore

³⁵trans. note : possibly, purification.

³⁶trans. note : (left over from the previous chapter) *Opera omnia* is the name given to the collected works of Fabricius

transform into a general note, elsewhere?

contractions chase the blood to the periphery through the vessels, it is according to Descartes a viscera whose movements manifest passively the effects that its own heat determines in the blood that falls in its cavities, whose walls³⁷ have a limited elasticity. It is thus the diastole and not the cardiac systole that correspond to the active phase of the movement of circulation (1). There is barely need to explain that, in proposing this explanation of the circulation of blood and of the movement of the heart by action of an eminent heat (2), Descartes does not have the feeling of breaking with the mechanistic explanation of the functions of the living being, since he assimilates this heat to that engendered by the fermentation of hay or of raisin (3). It remains nonetheless however that the comparison brings us back to a phenomenon of vital or at least chemical type and not anymore of mechanical type. There is well a difference between a fermentation and a clock movement³⁸. It would have been more Cartesian to assimilate the heart to a pump, as had done Harvey, as Willis is bound to do.

The animal spirits, born in the heart (4) and moved at first in the same way as the blood only remain / reside³⁹ in the brain but as in a wind box. From the brain, they determine all the movements of the animal organism — with the sole exception of the movement of the heart — following⁴⁰ the structure of the muscles and of the nerves. Descartes says of the muscles that they are balloons filled with spirits whose longitudinal shortening, under the effect of transversal dilation, mobilizes the articulated bones or the organs, the eye for example, on which they are inserted (5). It's little from the morphological point of view, but it's enough for the Cartesian physiology of movement. On the structures of the nerves, Descartes is more expansive / has more to say. Any nerve is a bundle of fibers inside

(1) On the arguments that Descartes opposes to Harvey see the *Description du corps humain*, A.-T., XI, p. 241-45. "It is only this rarefaction of blood that is the cause of the movement of the heart" (p. 244).

(2) "There is always more heat in the heart than in another place / location of the body" (*Discours*, Vth Part).

(3) *Ibid.* — On the mechanistic explanation of the phenomenon, see the *Principes de la philosophie*, IV, art. 93 : *What is the cause of the fires that burn or warm but do not glow : just like the hay that warms on its own.*⁴¹

(4) Article 10 of the *Traité des passions* has for title : How the animal spirits are produced in the brain. In fact, DESCARTES shows there that the spirits come from the heart in the form of "highly subtle parts of the blood". They don't undergo "any other change in the brain" only a separation from the "other parts of blood less subtle". Thus there is no contradiction between this affirmation and the one according to which the heart is the "source" of spirits (*Traité de l'homme*, A.-T., XI, p. 13 ; BRIDOUX, p. 814).

(5) *Traité de l'homme*, A.-T., XI, p. 134 and p. 137 ; BRIDOUX, p. 817 and 820.

³⁷trans. note : parois.

³⁸trans. note : d'horlogerie.

³⁹trans. note : séjournent.

⁴⁰trans. note : selon.

⁴¹trans. note : *Quelle est la cause des feux qui brûlent.*

of a pipe, a marrow made of nets prolonging the cerebral marrow and fairly loosely ensheathed (1). Calling up an image borrowed from modern technology⁴², let us say that Descartes sees the nerve as an electric wire under [a] tube. Being a bundle of cords, the nerve is organ of the sensitivity (2), as a pipe, the nerve is organ of the motricity (3). Descartes hence does not distinguish, as do Galen and the Galenists, sensitive nerves and motor nerves. Any nerve is at once, but through different aspects of its structure, and according to different mechanisms, sensitive and motor. The centripetal sensory excitement isn't something that might propagate along the nerve, it is an immediate and integral traction of the nervous fiber. When the animal sees, smells, touches, hears, tastes, it is the surface of their body that shakes the brain by the means of the nervous net. The centrifuge motor reaction is very well, as for itself, a propagation, a transport. The spirits rush through the pores of the brain opened under the effect of the traction of the fibers, make their way in the free space in-between contained fibers and containing pipe. Pressed, they press ; pushed they push. Hence the swelling, that is to say the contraction of the muscle (5). Not at any moment, in none of its phases, does the involuntary movement allow itself to be confused with an action. That is what, with a lot of perspicacity, Mr. Dreyfus Le Foyer has noted : "Nerves bring nothing that comes from them in their response to a stimuli/excitement ; they are torn like wires or traveled like routes. As for the muscles, they don't contract any more than the propulsive organ. Like it, they let themselves be passively distended (6)."

It is of high importance to imagine / conceive of this heterogeneity

(1) *Dioptrique IV*, A.-T., VI, p. 110 ; BRIDOUX, p. 202.

(2) *Ibid.*, p. III ; BRIDOUX, p. 203.

(3) *Traité de l'homme*, A.-T., XI, p. 133 ; BRIDOUX, p. 816.

(4) *Dioptrique IV*, A.-T., VI, p. 111 ; BRIDOUX, p. 202. It seems that Guillaume Rondelet (1507-1566) of Montpellier, friend of Rabelais, was the first to suppose that each nerve is composed of independent bundles of centripetal and centrifuge conductors.

(5) In his 1664 preface to *Traité de l'homme*, CLERSELIER makes the remark that the insertion of the nerve in the muscle and following dilation of the muscle through the spirits have been poorly figured by Louis de La Forge who thought that the nerves discharge / unload⁴³ in the muscles and there pour the spirits, while Descartes taught that "the nerves spread their fibers or their branches in the muscles themselves, and that depending on the diverse disposition of these fibers or of these branches, when they are swollen or un-swollen, they swell or deflate the muscles, and produce different effects..." (A.-T., XI, p. xx). It is incontestable that Clerselier is right on this point.

(6) Les conceptions médicales de Descartes, in *Revue de Métaphysique et de Morale*, January 1937, p. 247.

⁴²trans. note : technique.

⁴³trans note : se déchargent.

of the mechanisms of the excitement and of the reaction and the structures on which they depend. And that is why we want to cite the text which, to our knowledge, could appear to be in contradiction with the theory whereby sensitivity is in no case the matter of the animal spirits. "The spirits flow from the brain through the nerves in all the muscles, by way of which they dispose these nerves to serve as organs for the exterior senses : and swelling diversely the muscles give the movement to all the members" (*Description du corps humain*, A.-T., XI, p. 227). The important term here is "dispose". And the meaning⁴⁴ of this term is given to us, without possible ambiguity, by a passage of *Traité de l'homme*, where it is said that the animal spirits, by swelling the nervous pipes through which they get to the muscles, on one hand prevent the nervous nets from being pressed in their sheaths / sleeves, on the other, maintain them in a state of tension (1). Thus the animal spirits, all while assuring their essentially motor function, contribute to the perfection of the function of sensitivity, by disposing the nerves, as bundles of cords, to correctly fulfill their role of solid liaison/connection between the organ of the sense and the brain. Said otherwise, the animal spirits facilitate moreover the transmission of sensory stimuli / excitement with which they have nothing to do. Descartes intends to refute a possible objection, namely that the functions of sensitivity attributed by him to nervous fibers, based on a mechanism of traction, should require that these fibers be rectilinear and tensed, which the anatomy of nerves contradicts. In fact, the objection had been made by Borelli in his *De motu animalium* (1680-81) (2).

We can now usefully ask ourselves the question of knowing if ~~the~~ anatomical and physiological conceptions in matters of sensitivity or of movement enable, or not, Descartes to form by anticipation a sketch of the concept of reflex, in the sense that this term has received progressively from the first third of the XIXth century onward. If the legend is truer than history, we should admit with it that Descartes had glimpsed this notion because he needed to see it, in reason of the mechanical nature of his physiology. But if we admit that logic never loses its rights, we must ask ourselves, when it contradicts the legend, if it

(1) A.-T., XI, p. 143 ; BRIDOUX, p. 824. See also *Traité des passions*, art. 12.

(2) IInd Part, Proposition 156 : Borelli says that the nerves are not similar to a cithara's cord, they are neither tensed, nor stretched in a straight line, they are sinuous, inflected, their terminations are not solid but soft⁴⁵. Consequently sensitivity is not explained by the traction of the fibers (p. 342 of the edition of Naples, 1734).

⁴⁴trans. note : sens.

⁴⁵trans. note : molles.

would not be suited, in doing the history of a legend, to reestablish a non legendary history. This is a work that, to our knowledge, has never been undertaken seriously, even by the best historians on the question, even by the most complete who is incontestably Franklin Fearing. One must say that too often the physiologists who have shown an interest in the history⁴⁶ of the reflex have shown a lack of critical spirit while the philosophers have most of the time, especially/notably in France, found in their philosophical admiration for the Cartesian biology and in the insufficient information of biology found in their own philosophy two conjoined reasons of not being more demanding than the physiologists. Moreover it is a constant that the motivation of any critical enterprise contains some ambiguity and that by reexamining closely titles of a great mind⁴⁷ with respect to his reputation one takes the risk of passing for a bitter, nasty spirit. One must know to take risks, thinking that the restitution of the truth, in such matters, makes one with the redistribution of merits and the reparation of injustices.

Fearing notes on multiple occasions that Descartes is ordinarily given the credit (*Descartes is usually credited* [in English in the original]) for the discovery of the reflex movement (*the discovery of reflex action* [in English in the original]). But what is astonishing, in our eyes, is that, making pertinent reservations about this usual claim, he never asks himself the question of knowing through whom, when and how this claim was formulated for the first time before becoming a widespread opinion. "It is perhaps more exact, remarks Fearing, to say that he [Descartes] was the first to publish a systematic study of the phenomenon of involuntary movement (1)." Very precisely, Fearing thinks that the *concept* of reflex is implicitly contained (*Such a concept is implicit...* [in English in the original]) in the theory of the automatism of beasts and that the *word* reflex in his current usage is found in article 36 of *Traité des passions* (2). Yet we find the affirmation, rigorously inverse, in a book by Sherrington, posterior to the study of Fearing: "The notion of reflex action goes back to Descartes, but not the term; the term is more clearly detectable in Willis (3)." Fearing and Sherrington

(1) *Reflex action*, p. 26, n. 12.

(2) *Ibid.*, p. 26.

(3) *The Endeavour of Jean Fernel*, p. 84: "The notion of reflex action is traceable to Descartes, but the term hardly. The term is traced more clearly to Thomas Willis. Descartes did not consider all our acts to be reflex." [in English in the original⁴⁸]

Mr. Gösta EKEHORN, in his *Commentary* of Sherrington's book, writes also that the Cartesian conception implies the idea of reflex action, that Descartes has the first formulated it, that he is its father. Cf. Sherrington's Fernel Comments, in *Acta Medica Scandinavica*, vol. 127, suppl. 187, Stockholm, 1947, p. 49-50.

⁴⁶trans. note: C often opts for the philosophy ~~near~~ or philosophically infused term of "l'historique", uncommonly used ~~as a noun~~ (as opposed to l'historien). *

⁴⁷trans. note: esprit.

⁴⁸trans. note: in turn, the in-text quote appears to have been translated and, in doing so, simplified based on this.

relatively

this note
may
need to
be revised

* This becomes of 37 primary importance
in chapter 7. see note 14, p. 137.

in sum, dismember, each in their own fashion, the thesis following which one could find, for the first time, in Descartes, the *concept* and the *word* of reflex, a thesis defended by the German physiologist Eckhard, in 1881, with reference to article 36 of the *Traité des passions* (1), thesis that Fearing knows well, from which he borrows the reference to the only passage of Descartes' oeuvre that gives him an appearance of solidity, but of which he neglects curiously and to go back to the historical source and to verify scrupulously if it is really located in the text of Descartes the very same which it pretends to be extracted from.

We do not ignore the two figures in *Traité des passions* (7 and 37) representing the retraction of the leg or the arm (noniceptive reflex of flexion, in response to a burn), and of which the first has been reproduced very often, will always continue to do more to give credit to the Cartesian origin of the notion of reflex, than a thoughtful reading⁴⁹ without prejudice can do to contest it. We are nevertheless going to attempt to distinguish definitions and denominations, of weighing the text - and the contexts - and to avoid the illusions of retrospection. We wish to first recall that the term reflex [*réflexe*, in the original] was an adjective before becoming a substantive. The physiologists of the first half of the XIXth century only used it when joined to the terms of movement, of action, of process, of phenomenon. In 1876, in the *Dictionnaire* of Dechambre, reflex is always only taken as an adjective : *Réflexe* (Action) (2). Likewise reflex is only an adjective in tome IV of the *Dictionnaire* of Littré (1878) and only becomes a substantive in the *Supplément* (1879). As adjective, the term of reflex succeeds, in the XIXth century, to the term *reflexus* which the authors of the XVIIth and of the XVIIIth centuries attached to the term *motus*. We should therefore not be astonished of not encountering in the writings of Descartes the term of reflex, but we should note that the terms of reflex movement which we could, maybe, encounter there, are not found there any more. If the word is not found there, there is a high chance *a priori* that the notion can not be found there. Properly speaking, there is only notion or concept where there is, at least in essay or sketch, a definition, that is to say a relation between a defined and a defining⁵⁰. Without demanding of a precursor that they should be able to formulate with

italics

(1) Geschichte der Entwicklung der Lehre von der Reflexerscheinungen, *Beiträge zur Anatomie und Physiologie*, IX, Giessen, 1881, p. 35.

(2) *Dictionnaire encyclopédique des sciences médicales*, A. DECHAMBRE director ; 3rd series, tome III, 1876, p. 27. The article is signed Laborde.

⁴⁹trans. note : lecture attentive

⁵⁰trans. note : rapport entre un défini et un définissant.



FIG. I. — *Traité de l'homme*, figure 7
(DESCARTES, *Œuvres*, Adam-Tannery, XI)

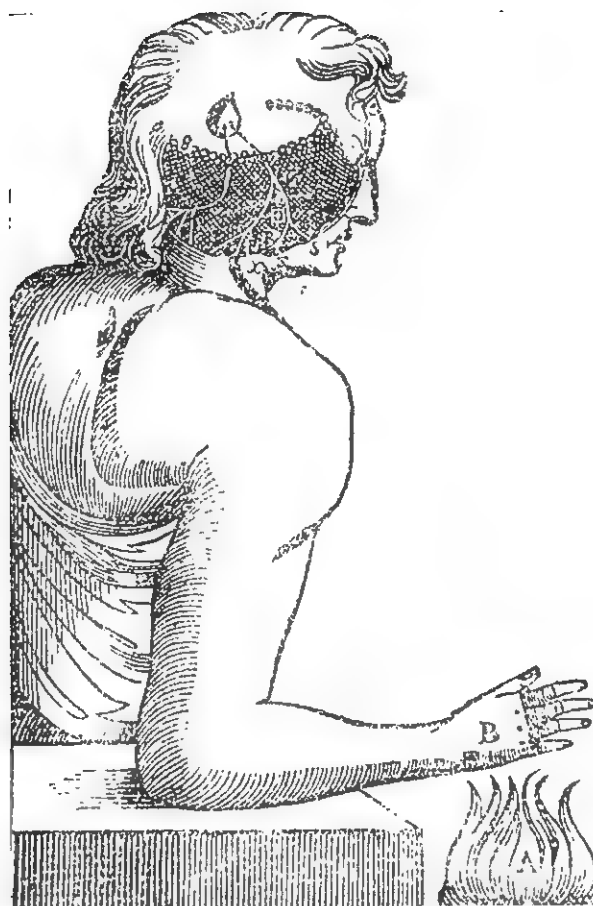


FIG. II. — *Traité de l'homme*, figure 37
(DESCARTES, *Œuvres*, Adam-Tannery, XI)

precision what the trials and errors⁵¹ have allowed to his successors to conceive with more clarity, without holding against him⁵² to not satisfy the conditions posed in 1905 by the mathematician Lebesgue for any effective definition : "An object is defined or given when one has pronounced a finite number of words applying to this object and it only", we cannot hold for the equivalent of a theory neither a general theory as is the Cartesian explanation of involuntary movement, neither, to a greater degree⁵³, a reminder/summary⁵⁴ of observations of which many go further back than the author. And it seems to us that is it to abusively confuse everything that a critical analysis must separate to write, like Mr. Minbowski : "The notion of reflex was established by Descartes based on the observation of that fact that when one approaches rapidly an object with eye^{the}, the result is a blinking of the eyelids, involuntary and impossible to repress (1)."

The essence of the concept of reflex is not only that it contains the element or the abstract / abridged version⁵⁵ of a mechanical explanation of muscular movement, it is to admit that from the periphery of the organism leaves a trembling/shaking⁵⁶, whatever its nature, which, after reflection in a center, returns to that same periphery. What distinguishes the reflex movement, is that it does not proceed directly from a center, the central seat⁵⁷ of an immaterial power of some sort. In that resides, in the kind/type of the movement, the specific difference between the involuntary and the voluntary. But, according to Cartesian theory, the movement which manifests itself at the periphery, in the muscle or in the viscera, takes its source in a center, the center of all organic centers, the cardiac home [foyer]. No doubt is it a a center of action that is material and not spiritual. And that is why it is incontestable that the Cartesian theory is a mechanical theory, but it is not ~~a~~ theory of the reflex.

the

(1) *L'état actuel de l'étude des réflexes*, translated from the German by H. EY, 1927, p. 1.

⁵¹trans. note : tâtonnements.

⁵²trans. note : tenir rigueur.

⁵³trans. note : à plus forte raison.

⁵⁴trans. note : un rappel.

⁵⁵trans. note : abrégé.

⁵⁶trans. note : ébranlement.

⁵⁷trans. note : siège.

[...] And that's why it is incontestable that the Cartesian theory is a mechanical theory, however it is not the theory of the reflex. There is more. The image itself which has suggested the invention of the word of reflex, that of a light ray reflected by a mirror, imposes that there is a homogeneity between the incident movement and the reflected movement. Yet it is the contrary in Descartes. The excitation of the sense, the contraction of the muscles are two movements that bear no relation of analogy both on account of the nature of the mobile as the mode of efficacy. What in common between pulling on the rope of a bell and blow⁵ in an organ's pipe⁵? In both cases, we are dealing with a mechanical phenomenon. It is clear also that the one can command mechanically

⁵trans. note : orgue, i.e. the instrument. ≠ organe, i.e. the medical, physiological term.

the other (1). But, except for attributing to the terms that we use/employ no well defined meaning, if we can affirm without error that Descartes has described in the most modern spirit the phenomena of neuro-muscular automatism, if we are founded / justified⁶ to consider close / draw near⁷, as for the project, the mechanical theory which he has given of it and the theory of reflex which, through generalization of the concept, most physicians of the XIXth century have adopted with the aim of [providing] mechanistic explanations for the automatic movement and sometimes even the voluntary movement, it appears abusive to us to lend to Descartes the anticipation of a concept which the fundamental ideas of his anatomy and of his physiology disallowed/forbade⁸ him to form.

But we must necessarily show why some, in the works of Descartes, could pretend to find the term of reflex. As we have seen above Fearing adopts the opinion of Eckhard, without having the curiosity to go back to Émile Du Bois Reymond, of whom Eckhard himself invokes the authority. In article 36 of *Traité des passions*, we find the words : *esprits réfléchis*⁹. There is the only reference of our authors, reference whose weight we must carefully determine. Let us first consult the context. Descartes explains in article 12 how exterior objects act /work¹⁰ on the sense⁵, and in article 13 how this action has for effect certain independent movements of the soul. It is on this occasion that he takes / chooses for example the involuntary blinking of the eyelids, [an] indisputable reflex movement. However, from article 17, Descartes deals¹¹ with the functions of the soul and, having defined in article 27 what one must understand by passions of the soul, takes on, with this definition explained, the union of the soul and the body. In article 34, he explains how the soul and the body act one against the other, through the mediation of the pineal gland, and in article 35, he gives an example for the way in which the impressions of objects unite in the gland which is in the middle of the brain. This example concerns the visual perceptions and, on this matter, Descartes gives to the spirits a role, of which he says⁶ very little by the way, in the transport to the gland, on which they superimpose / juxtapose¹², of images formed thanks to the optic nerves "on the interior surface of the brain with view of its concavities". The spirits prolong up to the gland the action of the nervous fibers

(1) Descartes, besides, does not say anything else/different. "But it is owing to the machine of our body being so [extremely] composed that the movement of this hand towards our eyes excites another movement within our brain, which leads / conducts¹³ the animal spirits in the muscles that make the eyelids lower." (*Traité des passions*, art. 13, fin.) There is some difference between *un autre mouvement excité*¹⁴ and *un mouvement réfléchi*¹⁵.

⁶trans. note : fondé.

⁷trans. note : rapprocher.

⁸trans. note : interdisaient.

⁹[t.n. : reflected spirits]

¹⁰trans. note : agissent.

¹¹trans. note : traite.

¹²trans. note : superposent.

¹³trans. note : conduit.

¹⁴[t.n. another excited movement]

¹⁵[t.n. a reflected movement]

such that the union of the soul and the body be assured, ¹⁶it need be, by the common sense (1). However, in the *Traité de l'homme*, Descartes explains the formation of an optic image on the gland differently (2). It does not depend on the spirits which shock / shake¹⁶ it coming from the internal surface of the brain, but on the contrary on those that are coming out of it in the direction of that same surface and in the view of the nervous pores dilated by the traction[s] of the fibers of the optic nerve. And in *Dioptrique V*, Descartes, after showing how the retinal image is imprinted, in the form of shakes/trembling, by the fibers of the optic nerve on the internal surface of the brain, adds : "And there from I could still transport it towards a certain small gland located about in the middle of those concavities, and is properly the seat of the common sense (3)", however he says nothing about the mechanism of this transport. The context recalled, let's examine the text :

"And beyond this, if this figure is mightily strange and oh-so frightening, which is to say if it has lots in common with things that previously have been harmful to the body, this excites in the soul the passion of fright / apprehension, and following that of boldness, or otherwise that of fear and horror¹⁷, and depending on whether one has previously guaranteed oneself through guard or through flight against the harmful things to which the present impression is related ; because it renders the brain all the more disposed in some men that the reflected spirits of the image thus formed on the gland go from there to become part in the nerves that serve to turn the back or move / stir¹⁸ the legs in order to flee, and part in those that enlarge or shrink so very much¹⁹ the orifices of the heart, or that agitate so very much the others part²⁰ from where the blood is sent to it that this blood there becoming rarefied in another fashion than is usual, it sends some spirits to the brain that are fit to maintain and fortify the passion of the fear, etc."

20

It seems manifest to us that the example here analyzed is not the one of a reflex, as was the one of article 13. Talk is of a behavior²¹ affecting the totality of the body and not of a segmented movement. But mostly we are dealing here with a behavior in which the reaction is not univocally determined and uniform in all subjects and in any case. To speak of reflex, on the occasion of this example, one must confuse under this term all sorts of instantaneous and automatic reactions, and one must not see / glimpse that, even if the initial reactions to the encounter of

(1) Cf. *Letter to Mersenne*, April 21st 1641, A.-T., III, p. 362 ; BRIDOUX, p. 1117. *Traité des passions*, art. 31 and 32.

(2) A.-T., XI, p. 174-176 ; BRIDOUX, p. 850-861.

(3) A.-T., VI, p. 120 ; BRIDOUX, p. 261.

¹⁶trans. note : choquant.

¹⁷trans. note : crainte . . hardiesse peur et épouvante.

¹⁸trans. note : remuer.

¹⁹trans. note : tellement.

²⁰trans. note : "Et outre cela, si cette figure est fort étrange (. .) la passion de la peur, etc."

²¹trans. note : conduite.

the object were reflexes, the reactions here described by Descartes have precisely for end to avoid a situation in which there would be for the organism no other possible reaction than a reflex reaction. Then we could be tempted to read this text like a presentiment of a concept of conditioned reflex, such that unable to hold Descartes for a precursor of Marshall and of Johannes Müller, one could at least hold him to be a precursor of Pavlov (1). In fact the direction imprinted on the spirits through their shock against the pineal gland is determined by the affective quality of anterior experiences. But we must observe still that, in the Cartesian example, we are not dealing with a conditioned anticipation of an unconditioned response to a given stimulation ; on the contrary we are dealing with, under a given stimulation, the invention of a different response. As P. Guillaume says : "When a child responds to the threat of a blow/beating with a parry²², extending the hand to protect themselves or to deflect the blow, this response is outside the frames of the classic conditioned reflex, because never did the blow *received* condition this parry (2)." In summary, we must note that in the cases where he uses examples of automatic movements to which it is authentically suited to give the denomination of reflex, palpebral reflex or noniceptive reflex of flexion of the members, Descartes never speaks of reflection of the spirits, for the simple reason that the spirits do not have, according to his explanatory schema, any role to play in the centripetal conduction of the sensory impressions²³, and that the one time, where he writes the words "esprits réfléchis"²⁴, the example given by him does not concern any type of reflex, either absolute, or conditional.

We would gladly [like to] invoke to support our interpretation

(1) On this point see rather *Letter to Mersenne*, March 18th 1630, A.-T., III, p. 137 ; BRIDoux, p. 925-928.

(2) *La formation des habitudes*, Paris, Alcan, 1936, p. 54. The pertinent critique that Guillaume proposes, not of the notion of conditional reflex, but of its generalization, merits to be read in full (p. 50-55) as commentary of articles 35 and 36 of *Traité des passions*. We will quote this passage still : "When an event becomes a habitual signal of another event which possesses a biological value, the response is a *preparation* which can take on other forms than anticipation. In general, one does not react to the menace of pain by reactions of pain, but by attitudes of fear or of protection against pain which can differ greatly from the former... The child that makes the experience of the burn does not react to the sight of the flame by retracting his hand and crying, but he does not come near any more" (p. 53).

We also signal the pages in which Mr. Pradines, referring to Guillaume, puts the greatest care in distinguishing the reflex properly speaking ^{from} all the forms of adaptive behavior whose exterior appearance²⁵ is apparently that of the reflex. Cf. *Traité de psychologie générale*, I, 1943, 1st Part, section 1, chap. II : "L'activité réflexe", p. 80-87.

²²trans. note : parade.

²³trans. note : impressions sensibles.

²⁴[t.n. reflected spirits]

²⁵trans. note : allure

the critical note that H. E. Hoff and P. Kellaway dedicate to this same article 36 of the *Passions de l'âme*, in their excellent study *The early history of the reflex*, note in which they specify that Descartes uses the term "réfléchi"²⁶ to describe the mechanism not of a simple response of the motor nerve to an afferent stimulation but of a response more complex implicating a relation to the soul, and variable depending on the disposition of the soul, of the individual constitution and of past responses. Yet at the same time we must distance ourselves from these two authors when they seek, as the first to our knowledge, but too ingeniously for our taste / according to us, to detect the notion of reflex in the interpretation of a figure of the *Treatise of Man* that a more careful reading of the corresponding text forces, no doubt possible, to hold for erroneous. This figure is meant to illustrate the first part of an explanation relating to the conditions in which the pineal gland can, due to its position inside the brain, dispose "the spirits that come out of it, to take their course towards certain places of the brain over others". The first of causes invoked by Descartes is the difference of size and force/power of the "small parts of the spirits coming out of it", difference explaining the diversity of actions exercised by these flux of spirits on the interior surface area²⁷ of the brain and their power to turn the small nervous pipes where they are ready to pour in "towards the places where they exit, if they aren't already fully turned ; and by this mean, of being able to move the members related to these pipes, towards the locations to which are related the places of gland H's surface area". Descartes explains by this that idea of a movement, as much as it can be said to ^{be} cause of movement, "does only consist in the manner in which the spirits leave this gland for the time being"²⁸. One must thus read Descartes' text upside down in some sort to be able to say/claim, as do Hoff and Kellaway, with support from figure 63 (fig. 33 of the boards of the Adam-Tannery edition), that the identity of treatment of the light ray reflected by the object towards the retina and the animal spirits reflected by the gland towards the cerebral insertion of the optic nerve is manifest (1). In fact, the figure does not impose manifestly²⁹ any interpretation of this kind, and the text of

(1) The early history of the reflex, *Journal of the History of Medicine*, vol. II, n° 3, 1952, New York, p. 211-249.

The critical note on article 36 of *Passions* is found p. 237 n. 25. The interpretation of figure 63 (33 of Adam-Tannery) is found p. 237.

For the text of the *Treatise of Man* illustrated by the figure in question, cf. A.-T., p. 179-184 ; BRIDOUX, p. 854-859.

[t.n. reflected]

²⁷trans. note : superficie.

²⁸trans.note : pour lors.

²⁹trans. note : could be translated as obviously or evidently; but at the cost of losing the comedy, the relationship to Pascal and his (arguably swollen) language, Hoff and Kellaway's reading etc. etc..

Descartes, for which this figure is made by an artist / illustrator³⁰ other than Descartes, imposes manifestly the opposite interpretation. In the example³¹ invoked, it is not the light ray coming / originating from³¹ the object that is the cause of the manner in which the gland is supposed to be hit by the intra-cerebral spirits, it is on the contrary the manner in which the spirits exiting the gland orient the intra-cerebral orifice of the nerves commanding the movement of the term that are the cause of the manner in which the arm turns toward the object. The starting point for the mechanism that adjusts a movement of the body to an exterior object is not³² the object but in the gland. Descartes himself takes a lot of care in repeating that in the first part of this explanation he does not consider the position of the gland only as it depends on "the sole force of the spirits and without that the reasonable soul not³³ the exterior senses contribute to it". One must thus conclude that by searching here for a proof that Descartes had treated univocally of the reflection of light rays and the reflection of the spirits, we add to the reading of Descartes a prejudice of interpretation that his *renascent / returning*³² vigor to us does not seem at all sufficient to give credit to / *accredit / substantiate*³³.

If a too great subtlety were to be found in our attempt [essay] to correct some broken readings³⁴, it remains to hold against Descartes that same argument which following Pascal has often and legitimately been raised in his favor, concerning the *accusation* ^{his} that has been made against it to have taken in Saint Augustine the foundation of philosophical revolution, the *Cogito ergo sum*. "I know how much of a difference there is, says Pascal in *L'art de persuader*, between writing a word with [a jolly sense of] adventure without giving it further or longer reflection, and perceiving/glimpsing in that word an admirable sequence of consequences, that prove the distinction of material and spiritual natures, to make of it a firm and sustained principle of an entire physics, as Descartes had claimed to do." It would be stupid, of course, to reproach to Descartes to not have known to make of his "reflected spirits" the sustained principle of an entire reflexology, but one can, without irreverence, refuse to admire the sequence of consequences that some historians of the neuro-muscular physiology have thought to draw from two solitary words.

One understands very well, by the way, this generalized temptation to look in the writings of Descartes for a concept of which his thought has produced so many elements, and to complete, in his stead / place, a trajectory on which he has accomplished so many steps. He who formulated the law of the reflection of light rays (*Dioptrique*, II), the one who, in the article 35 of *Passions* speaks of the light reflected by the body of an animal

³⁰trans. note : dessinateur.

³¹trans. note : en provenance.

³²trans. note : renaissante.

³³trans. note : accréditer.

³⁴trans. note : défectueuse.

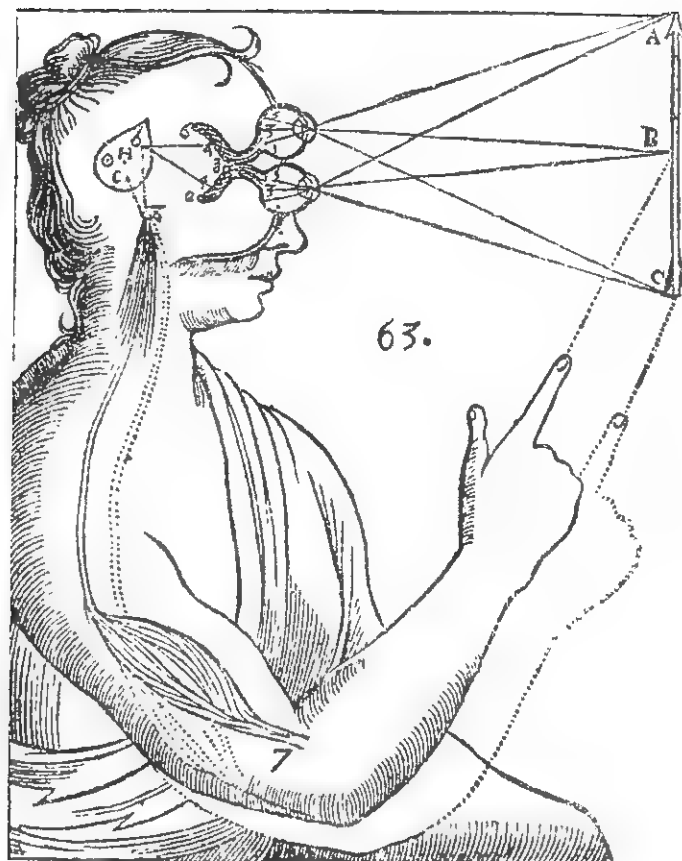


FIG. III. — *Traité de l'homme*, figure 33
(DESCARTES, *Œuvres*, Adam-Tannery, XI)

he ~~could~~
had been
able to
(alternative)

in our eyes, as well as the radiation³⁵ of the optic image thus formed towards our pineal gland, who in the article 36 of the same treatise speaks of the reflected spirits of this image on the gland, how could ~~he~~ not convert a concept of geometric optics into a concept of geometric physiology? We must answer that admittedly³⁶ he could have known if he could have [done it]³⁷. But the thought of Descartes obeys to the logic of the knowledge of Descartes and not to the knowledge of his successors.³⁸ All the concepts are tightly linked in a mind/spirit as systematic as that of Descartes. All his anatomical and physiological theories on the movement of the heart, on the origin and nature of animal spirits, on the heterogeneous structure of the ways of sensitivity and of motricity composed as many obstacles for him, but more in the sense of screens than of delays. And if it is true that as soon as, in a physiology of a mechanistic spirit as was that of Descartes, and elsewhere as little experimental as was his, we admit, in addition to the anatomical and functional parenthood/kindship³⁸ of the heart and the muscle, the identity of the mechanism of sensitivity and of movement and the identity if not unity of the nervous ways of centripetal and centrifuge propagation, the word and the outline³⁹ of the notion of reflex movement there have easily found their place. We do say : have found their place there, we do not say : have appeared there.

We intend here to speak about the Italian school of iatromechanics of which Santorini (1561-1636) is undoubtedly the precursor through his *Ars de medicina statica* (1614), but of which Borelli (1608-79) is certainly the founder. In the *De motu animalium* (1680-81) Borelli affirms like Harvey that the heart is a muscle and functions as such : *Est procul dubio cor unis ex musculus praecipuis animalis... Dicendum est cor eodem modo et ab iisdem causis inflari et contrahi a quibus caeteri muscoli moventur* (1). He holds the nerve for a bundle⁴⁰ of fibers surrounded by a membrane. The nervous fiber is not hollow like a reed⁴¹, it is a cylinder of spongy substance analogue to the pith⁴² of the green elder⁴³, along which flows a liquid spirituous succus, the nervous succus⁴⁴ (2). The muscles are composed of fibers comparable to contractile chains made of rings and able to be retracted under the action of coins (*cunei*) which distend them (3). These coins are the fermenting particles of the blend⁴⁵, operated inside the muscle, between the nervous succus and the blood. By admitting that it is the muscular fiber itself which

(1) Edition of Naples, 1784, p. 206.

(2) *Ibid.*, p. 214-217.

(3) *Ibid.*, p. 22.

³⁵trans. note : rayonnement.

³⁶trans. note : certes.

³⁷trans. note : il l'aurait su s'il l'avait pu.

³⁸trans. note : parenté.

³⁹trans. note : ébauche.

⁴⁰trans. note : faisceau.

⁴¹trans. note : roseau.

⁴²trans. note : moelle (normally translated as marrow, in the medical context; here the context being that of botany, as part of an analogy).

⁴³trans. note : sureau vert.

⁴⁴trans. note : suc.

⁴⁵trans. note : mélange.

*trans. note : another warning by Canguilhem before judging ⁴⁸ the past from the point of view of the present. See also, for example, page 2 of the foreword and critique of Fearing's approach.

Also p 156
(truth of the
way of
the critique of
the crit.

Also, p. 107
the critique of
the crit.

shortens ^{itself}, in the fashion of a wet cord (*funis madidus*), Borelli is on the side of the opinion of Steno and distinguishes himself manifestly from Descartes. But the opposition to Descartes is clearer still in the ways and means of the sensitivity. It is not explained by the traction of the fibers, but by the undulatory⁴⁶ movement of the nervous succus (*undulatio succi spirituosus*) (1). It must thus be admitted that through the same nervous ways two inversely directed movements of the nervous influx spread (*per easdem via nervorum duos motus*⁴⁷ *contrarios as extra et ad intra fieri necesse est*) (2). How to explain then that, simultaneously, two inverse movements are propagated, that for example at the same moment the muscles feel the sting⁴⁸ of a glaive⁴⁹ and energetically contract themselves? One could think that the local movement and the sensory movement⁵⁰ do not propagate along the same fibers, but it is more likely that the undulation of nervous succus can not be conceived independently of a reciprocal movement in opposite directions (*motus reciprocus ante et retro*) (3). Let us not be surprised hence to see Borelli distinguish two directions of nervous flux and speak of a retrograde movement (*motus retrogradus*). We do not have quite fully the *motus reflexus*, in a mechanistic physiology, but we have the equivalent.

It's in Baglivi (1668-1707) that we find the terms of movement reflex in the expose of a mechanistic theory of muscular contraction. In his *De fibra motrice specimen* (1700), Baglivi teaches that the first motor of all muscular movement is the movement of the dura mater. This envelop of the brain is agitated by oscillations that are prolonged, through continuity and alongside the nervous fibers, up to the periphery of the organism. Baglivi does not admit the existence of animal spirits, but admits, like Borelli, that of a nervous fluid pushed which contributes to the production of movement. This nervous fluid is pushed through the nerves towards the parts, which is to say the organs, by a systaltic or successive movement (4) of the dura mater. However, "as the dura mater is continuous with the parts, it happens that, through a sort of undulation, the occult systaltic or successive movements of the parts is reflected and

(1) *Ibid.*, p. 342 and 343.

(2) *Ibid.*

(3) *Ibid.*, p. 344.

(4) That is to say collected⁵¹ in the instant or divided through time. As we are dealing with an undulatory movement, one could say we are dealing with a wave or a train of waves.

⁴⁶trans. note : ondulatoire

⁴⁷trans. note : *motu*, giving the title chosen by so many of these Men (from Borelli's *De motu animalium*, Willis' *De motu musculari* to Harvey's *De motu cordis* to, going even further back, Galen's *De motu musculorum* to finally Aristotle's *De motu animalium*), continues to mean the movement. See also Canguilhem's anterior remark about reflex being previously used as an adjective, i.e. *reflexus*, in conjunction with *motus* [p. 38]. Relevant again as C. resumes talking about the *motus reflexus* [b.].

⁴⁸trans. note : pique.

⁴⁹trans. note : glaive.

⁵⁰trans. note : mouvement sensitif.

⁵¹trans. note : rassemblé.

eventually
separate
quote

jump, so to speak, on the dura mater (*mouvement systaltique réflexe*) and from it on the parts, due to the continuous fluctuation of the movements" (1). And in another passage: "For the orders of the soul to arrive instantaneously at the parts, the nervous fluids and the meninges receive the impressions from the direction determined by the soul and transmit them to the parts by the systaltic movement already mentioned. So that the impressions made by the exterior objects on the exterior senses be perceived by the soul, it must be that coming from the senses they arrive at the brain by the nervous fluid and also by the meninges themselves which prolong themselves in the sensory parts. This must be operated by a movement different from the first movement that we call reflex, because it is through reflection that they propagate in an instant from the parts to the first mobile of the dura mater. In order for no confusion to raise about these two movements, that is to say between the commerce with the senses and vice versa, we think that nature has created two meninges of which one is destined to receive the impressions of the soul and to transmit them to the sense, the other to receive the impressions from the parts made in them by the exterior objects and to transmit them to the brain, principal seat of the soul (2)." In his commentary of these texts, Daremberg writes that by neglecting the errors of physiology "we could maybe find there some germs of the modern ideas on the reflexes" (3). Such is not our opinion, for, on one side, the term of reflex movement here is imported, and on the other ~~the notion evoked~~ it designates calls for a remark unfortunately rather destructive than restrictive. Indeed, according to Baglivi, the point of reflection of the movements propagated along the nerves is found located at the periphery, while the essence/main part⁵² of the modern notion of reflex is that of an inverse centripetal forth⁵³ with a centrifuge return. Little this matters to us besides because, by citing Baglivi, we had merely aimed to show when and how the terms of reflex movement had introduced themselves in the mechanistic biology that is not that of Descartes. This introduction was done in two stages⁵⁴, thanks to the assimilation of the propagated movements by the nerves to an undulation: in Borelli (*motus retrogradus*), in Baglivi (*motus reflexus*). But we did say above that these terms which had found place in a mechanistic biology had not appeared there first. It is a fact that the writings of Willis are anterior

(1) *De fibra motrice*, I, chap. V. We cite here the translation of DAREMBERG in *Histoire des doctrines médicales*, II, p. 806.

(2) *Ibid.*

(3) *Ibid.*, p. 806 note.

⁵²trans. note: l'essentiel

⁵³trans. note: aller ... retour.

⁵⁴trans. note: en deux temps.

to those of Borelli and of Baglivi. The *De motu musculari* of Willis is from 1670. It is a fact that Borelli and Baglivi know the works of Willis as they cite it (1).

We thus believe to have established, by a sort of counter argument, that the formation of the concept of reflex movement found its main / principal obstacle in the Cartesian physiology on the site of the theories relatives to the movement of the spirits in the nerve and the muscle. Because the spirits play a role but, according to him, only in the centrifuge phase of the determination of involuntary movement, because their movement from the brain towards the muscle is a movement with no return, Descartes could not conceive, as Borelli and Baglivi were going to do, admitting the possibility of back-and-forth or of fluctuation movements propagated by the nerve, that the transport of some influx from the periphery to the center could be returned or reflected towards its point of origin / starting point. Descartes who admitted the circularly movement of blood admitted for the spirits, although born from the blood, only a movement of expansion channeled⁵⁵ in one unique direction⁵⁶. We have kept until now two points of the Cartesian anatomo-physiology relative, the first to the insertion of the nerve in the muscle, the second, to the dissipation of the spirits. As for the first point, Descartes held for certain that some valves, analogues to that of the veins, disposed in the nerve in its junction with the muscle were opposed to ~~the~~ the retrograde movement of the spirits, and we know that the poor knowledge⁵⁷ of this mechanism by Regius was, even more so than the undue/improper use that he had made of his master's unpublished works, the motive of the anger/scorn of Descartes (2). As for the second point, even though Descartes only had treated of it incidentally, it is clear that one needed to explain how, the heart pushing incessantly towards the periphery new spirits momentarily stored by the brain, the spirits, for which the reflux was

(1) On this subject we admit to not understanding why J.-F. FULTON, in the excellent historical Introduction of his work *Muscular Contraction* (p. 3-55) writes that BORELLI, given the date of publication of his *De motu animalium*, was not able to discuss the works of his contemporaries. He claims to have been unable to find in the oeuvre of Borelli any reference to Croone, Mayow, Willis or Glisson (p. 21). Yet, by reading Borelli, we have found the name of Willis cited on pages 217, 341, 413, 425 of the Naples edition of 1734.

(2) *Traité de l'homme*, A.-T., XI, p. 135-137 and p. 200-01 ; BRIDOUX, p. 818-20 and p. 872. The play/acting of the valves is used principally by Descartes to explain the coordination of the movements of antagonist muscles. — On the dispute with Regius see in A.-T., XI, *Descartes and Regius*, especially p. 681-683 ; and *Letter to Elizabeth*, March 1746, A.-T., IV, p. 626. — Sherrington refers to the text of the *Traité de l'homme* on the reciprocal innervation of the antagonist muscles of the eye in *The Integrative action of the nervous system*, p. 286-287 ; likewise BAYLISS in his *Principles of General Physiology*, p. 494-95.

⁵⁵trans. note : canalisé.

⁵⁶trans. note : a sense unique (one-way).

⁵⁷trans. note : méconnaissance.

impossible, ended up dissipating. Descartes admitted an evaporation through the pores at the surface [area] of the body, according to a mechanism of the imperceptible perspiration whose expose had made Sanctorious famous (1). *find*

We must now conclude. If one does in the work of Descartes the approximated⁵⁸ theoretical equivalent of certain attempts of constitution, in the XIXth century, of a general reflexology, we do not find there, considered well rigorously, neither the term nor the concept of reflex. It can never be said too often that it is the explanation of the heart's movement that contains in germs the ruins of all the Cartesian ~~philosophy~~. *physiology* Descartes was not able to see in Harvey's theory an indivisible whole. Granted he did feel that in the explanation of the movement of ~~the~~ heart *the* lied in the XVIIth century the key to the problem of movement (2). It would also be so in the XVIIIth century. A fact that turned out to be crucial, in the Baconian sense of the word, for any proposed explanation concerning the neuro-muscular production and regulation of movement, was the movement of separated/split organs and especially the heart. *the* If the brain does not send spirits any more to it, what determines their contractions? *for* Descartes did not have to ask himself this question. The separated heart retained its own heat and some traces of blood remained there which still were vaporizing and continued to dilate it (3). But for those who held the heart to be a muscle, it became difficult to admit that the brain could be the general and obliged/obligated⁵⁹ dispenser/provider of movements of all the organs. One thus needed to look elsewhere than in the brain *for* the condition, if not the principle, of certain movements.

In admitting like Aristotle that the brain was the seat of a proper elective heat and like Galen, as well as Fernel, that the heart is not a muscle, Descartes was driven to formulate

(1) *Traité de l'homme*, A.-T., XI, p. 135 ; BRIDOUX, p. 817-18 ; *Letter to Newcastle*, April 1645, A.-T., IV, p. 191 ; BRIDOUX, p. 1181.

(2) "And nevertheless it matters so much to know the real cause of the heart's movement, because without it it is impossible to know anything touching on the Theory of Medicine, owing to that all the other function^s of the animal are dependent on it as we will clearly see from what follows" *Description du corps humain*, A.-T., XI, p. 245.

(3) It is the argument that the P. Poisson advances, according to Descartes himself (cf. *Letter to Plempius*, March 23rd 1638, A.-T., II, p. 67), to defend the Cartesian opinion, against the objections of the P. Fabri. Cf. *Remarques sur la méthode de Monsieur Descartes*, Vth Part, 2nd observation ; p. 293 of t. II of the edition of 1724. — The example of the frog whose heart is excised or head sliced has manifestly embarrassed Descartes when the question was posed to him by a correspondent. He saves himself by saying that life does not consist as much in the movement of the muscles but in the cardiac heat. Cf. *Letters to Boswell* (?), 1646 (?), A.-T., IV, p. 686 and p. 695.

⁵⁸trans. note : approché.

⁵⁹trans. note : obligé.

** trans. note : a primary object of chapter 5 ("decapitated animals...")*

a doctrine of which Mr. Gilson, severe but just, declares that it "found itself aged and overcome⁶⁰ before even seeing the day of light" (1), and on the value of which nonetheless, Descartes, as he was to do for the theory of the propagation of light, declared himself ready to engage with any philosophy. "However, I am willing to accept that people think that if what I have said on this [subject]... turns out to be wrong, the whole rest of my Philosophy is worth nothing (2)."

Without anticipation as regards our last chapter and without double employ, we must ask ourselves if by accrediting Descartes with the original⁶¹ formation of the concept of reflex which his mechanistic biology appears to necessarily imply, some historians of physiology have not been driven towards that road through the grand facility with which many philosophers have consented for a longer time, and especially at the end of the XIXth century, to hold the Cartesian biology for an integral and coherent mechanism. We agree/grant besides that appearances are strong and very close to what we believe to be reality. We have already and elsewhere attempted to formulate some reservations on the opinion according to which the Cartesian mechanism would be effectively exclusive of any finality (3). We have found since in the studies of Mr. Gueroult a manner of encouragement in renewing them (4).

Descartes had well started proposing the constitution of what he had himself called a Theory of Medecine (5), that is to say a purely speculative anatomical and physiological science, as rigorous and exact as a mathematical physics, and susceptible to be converted into practical applications, that is to say therapeutics. Yet what ~~was to~~⁵⁸ be deduced from a physics of the human body, namely the determination of the vital utility, has never ceased to be present⁵⁹ in principles. We saw how, in the *Treatise of Man*, Descartes introduces the reference to instincts of our nature and to the distinction of desirable and harmful in order to define certain linked exterior movements, even though they are distinct, to the passions of the soul (6), such that a kind of vital valuation⁶² remains present in the determination of movements which ~~were meant to be~~, according to the initial project of a general explanation, but effects of the laws of the matter. Mr. Gueroult is thus founded in writing that Descartes began

from/of
it

should

should
only

(1) *Op. cit.*, p. 98.

(2) *Letter to Mersenne*, February 9th 1639, A.-T., II, p. 501.

(3) Cf. our *Connaissance de la vie*, Paris, 1952, p. 136-144.

(4) *Descartes selon l'ordre des raisons*, II : *L'âme et le corps* Paris, 1953, chap. XVII and chap. XX.

(5) Cf. *supra*, p. 52, n. 2.

(6) Cf. *supra*, p. 32.

⁶⁰trans. note : dépassée.

⁶¹trans. note : originaire.

⁶²trans. note : valorisation.

extended

with medicine conceived as a pure physics in order to reach higher / elevate himself to a medicine of the substantial human compound and "that one of the principal reasons he has had to confess his partial medical failure was the growing conviction that the mechanistic conceptions cannot suffice to elaborate a medicine, the human body being not a pure ~~plane~~ (expanse)⁶³, but also psychophysical substance" (1) But we ask ourselves - maybe in the trail traced by Mr. Gueroult and certainly with more temerity - if even the essay of a constitution of a general biology purely animal does not make apparent the resistance ~~to~~ of vital phenomena to their integral expression through their supposed mechanical equivalents. We have already highlighted / ~~picked out~~ raised this passage of *Primae cogitationes circa generationem animalium* where the commodities and incommunities⁶⁴ of animal nature are detected at the origin of the movements of the organism under consideration, either in its whole, or in its parts (2). It is true besides that Descartes who flatters himself for explaining "through the sole rules of mechanics" all that we call the natural animal appetites or inclinations (3), specifies in that same opusculum that "the brutes⁶⁵ have no knowledge of the advantageous or of the harmful" — which means exactly that they do not have the conscience/consciousness⁶⁶ nor the possibility to account for it⁶⁷ — and that it is only a matter ~~of~~ them of an acquired association between certain movements and certain occurrences that have enabled them to grow⁶⁸ (4). But undoubtedly we are reaching the limit of a mechanistic explanation. For these three aspects of life and of animal development : conservation, individuation and reproduction (5), are the expression of a specific difference between the animal machine and the mechanical machine. Admittedly, Descartes affirms constantly the identity of the one and the other : "For the moment that art is an imitator of nature and that Men can make various automata/automatons⁶⁹ in which without there being no thought, the movement is found, it seems conform

(1) *Op. cit.*, p. 248.

(2) Cf. *supra*, p. 32.

(3) *Letter to Mersenne*, October 28th 1640, A.-T., III, p. 213 ; BRIDOUX, p. 1088.

(4) *Bruta nulum habent notitiam commodi vel incommodi, sed quaedam ipsis in utero existentibus obvia fuerunt, quorum ope creverunt et a quibus ad certos motus impulsa sunt : unde, quoties illis postea simile quid occurrit, semper eosdem motus edunt* (*Primae cogitationes*, A.-T., XI, p. 520).

(5) *Accretio duplex est : alia mortuorum et quae non nutriuntur, fitque per simplicem partium appositionem, sine ulla earum immutatione, vel saltem sine magna... Alia accretio est viventium, sive eorum quae nutriuntur, et fit semper cum aliqua partium immutatione... Perfecta nutritio sive accretio simul generationem sive seminis productionem continet...* (*Excerpta anatomica : de accretione et nutrione*, A.-T., XI, p. 596. — Descartes opposes here the growth of an aggregate through parts unchanged and that of an individual through transformed parts.

⁶³trans. note : étendue. *See* ~~not 188F~~ p. 86 n. 15

⁶⁴trans. note : this formulation derives from the Latin.

⁶⁵trans. note : les brutes.

⁶⁶trans. note : conscience

⁶⁷trans. note : rendre raison.

⁶⁸trans. note : croître.

⁶⁹trans. note : automates.

Cartesian

For this point of ~~Descartes~~ philo sophy.

to reason that nature produces also its automata, but which are superior by far / prevail over the products of art, namely all the beasts (1), therefore the conclusion of another passage expressing the same idea : "... All things that are artificial are by this natural. Because, for example, when a watch shows the hours by the means of wheels that it is made of, that is no less natural for it than it is for a tree to produce fruits (2)." But is it not permitted to reverse the order of terms in the preceding relation and to say that all that is, in the animal organism, ~~is~~ natural, meaning mechanical, ~~is~~ ^{is} by this artificial, if it is true that God has built/assembled these sorts of automata that are the animals-machines and, having built/assembled them, has assured by the mechanical ways their conservation, their individuation and their reproduction, in one word the permanence of the ends allotted/committed to the assembly of their parts, ends inaccessible to our understanding and that, as a consequence, the science of living beings can and should neglect? Said otherwise, by giving himself a mechanical equivalent of the living. Descartes ^{only} succeeded in eliminating the ~~finality~~ ^{only} of the plan ⁽²⁾ of human knowledge ~~to carry it~~ ^{to carry it} ⁷⁰ forgetting it just as soon, over to the plane of divine action.

by And factually, if it is true that a clock badly made does not obey to other mechanical laws than a clock that is well set and that one can only distinguish them from the view of the "desire of the worker" and depending on "the usage it was destined to fulfill by the worker" (3), we must conclude that any machine that works is an arrangement⁷¹ of parts realizing an end that inhabits it without finding its principle in the laws according to which it realizes itself. If an animal that lives between good and bad is also a machine, it must also be inhabited by some end. Be this end foreign to the animal and that it is inaccessible to the understanding of Man does not fundamentally change the matter, without which there would be no difference between the living animal and dead animal, between the *accretio viventium* and the *accretio mortuorum*. Mr. Gueroult seems to us to have very well seen/glimpsed that if one does abstraction, as for the animal organism, of any finality proper, its indivisibility itself of organism is abolished. "In such conditions would it not be sufficient to cut off the hoof of a horse so that it is found to be *less horse than another* (4) ?" And if we admit that, in the singular case of Man⁷²,

(1) *Letter to Morus*, February 5th 1649, translation BRIDOUX, p. 1319 ; A.-T., V, p. 277.

(2) *Principes de la philosophie*, IV, § 203.

(3) *Méditation VI*, A.-T., IX, p. 67 ; BRIDOUX, p. 329-330.

(4) *Op. cit.*, p. 181.

⁷⁰trans. note : postpone, as alternative.

⁷¹trans. note : agencement.

⁷²trans. note : l'homme.

CHAPTER III

THE FORMATION OF THE CONCEPT
OF REFLEX MOVEMENT
BY THOMAS WILLIS

If the historians of biology and medicine agree on the presentation/expose of the principles and on the significance of the Cartesian biology even as they separate in their appreciations, on the contrary it is striking to observe how they have succeeded in giving of the work of Willis ideas the least bit compatible. It is so for example that Radl, ordinarily more insightful and exact, holds Willis for a "consequent mechanist", disciple of Galileo and Descartes (1), that Nordenskiöld identifies the neurobiology of Willis and that of Descartes (2). Inversely, and rightly, Guyénot links Willis with the iatrochemists, directly to Sylvius (Franz de le Boë, 1614-1672), indirectly to Van Helmont (3). It is certain that his contemporaries saw in Willis a chemist. "As soon had I began in practice that talk began of the chemical system of Van Helmont, then of those of Sylvius and of Willis", says Guglielmini (4). Willis does not hide/conceal his debts and his affinities with regard to the chemists in his *De fermentatione*. As for what belongs to physiology, he could find in Sylvius the theory of the formation of animal spirits in the brain and the

(1) *Geschichte der biologischen Theorien in der Neuzeit*, I, 2nd ed., p. 157.

(2) *Geschichte der Biologie*, 1926, p. 152-53.

(3) *Les sciences de la vie aux XVIIe et XVIIIe siècles*, p. 153. One should not confuse Sylvius (Franz de le Boë, 1614-1672) and Sylvius (Jacques Dubois) who was the master of anatomy of Vesalius.

(4) Guglielmini (1655-1710) was a iatromechanic of Padoa. We quote him based on DAREMBERG, *Histoire des sciences médicales*, II, p. 526. Note that Prochaska, in 1784, sees in Willis an illustrious representative of chemiatry, *celeber de secta chemica vir*.

cerebellum (1) ; he could not ignore that Van Helmont had assimilated to a luminous matter the Archeus¹ rector of organic phenomena. We should not forget finally to link all the chemists to Paracelsus whose influence in England was great/big in the XVIIth century (2).

But the historians of biology or the biological historians do not differ less as for the appreciation they have of the work of Willis. Fulton does not recognize to him any originality (3). Fearing thinks that his importance resides solely in his researches aiming at locating the function of the voluntary movement (4). On the other hand Jules Soury wrote, in 1899 : "Whether we consider the structure, the functions or the illnesses of the brain, especially the great neuroses like epilepsy or hysteria, there is not a single point of fact or of doctrine in which up to this day we can disentangle / extricate the influence of Willis and one is easily persuaded, by rereading the work of the old master, that the vivid force of his genius isn't yet depleted / exhausted (5)." Jean Lhermitte in 1925, goes even further than Soury and qualifies as "prophetic" the theory of the propagation of nervous influx proposed by Willis (6). Even if one professes for Willis a more nuanced admiration one is astonished by the judgment of Daremberg, who classifies him among the anatomists of second order from the XVIIth century, "as famous through his bad physiological and medical doctrines" (7), as through his description of the brain and the cranial nerves or the nosographic identification of sugar diabetes.

It is clear that, if by bad physiological doctrine one understands a system of propositions of which there remains nothing in the modern physiological treatise, Daremberg is right. However, not sharing his positivist conviction in the definitive validity of experimental facts which are supposed to owe nothing to some theory ~~quelconque~~, and asking ourselves what ~~what~~ shall remain in a century of the physiological doctrines that, in 1870, authorized Daremberg to distribute praise and blame, we are going to work to

(1) *Disputationum medicarum pars prima*, Amsterdam, 1663. The IVth Part is a dissertation *De spirituum animalium in cerebro cerebelloque confectione*, published in 1660.

(2) Cf. KOCHER, Paracelsian Medicine in England, in *Journal of the History of Medicine*, [sic] vol. II, n° 4, 1947, New York.

(3) *Op. cit.*, p. 17.

(4) *Op. cit.*, p. 58.

(5) *Op. cit.*, I, p. 428.

(6) *Les fondements biologiques de la psychologie*, p. 22.

(7) *Histoire des doctrines médicales*, II, p. 693.

¹trans. note : (alchemical) term associated with Van Helmont and Paracelsus.

work towards showing (alternat.)

show that Willis ranks among the great minds of the XVIIth century and among the great biologists of the pre-scientific era.

Thomas Willis (1621-1675) taught natural philosophy at Oxford and medicine in London. An open and curious mind, he knew to combine to the teaching of the chemists the reading of Descartes. We are dealing with a skilled anatomist whose name is not ignored by today's student of medicine. A great clinician also. It is as a practitioner that he becomes interested in the mechanism of muscular movement in order to better understand the nature of the disorders that his art tends to correct. It is the tetanic rigidity, the hysteric contracture, the choreic agitation, the epileptic convulsions that prompt him to study the neuro-muscular automatism. The physiology of Willis thus arises from the clinic and is clearly oriented towards pathogenesis. If the intentions of Willis are, of course, the same as those of Descartes, curing and preventing illnesses, one must recognize that the experience of the former are owed to a daily practice of an amplitude and variety missing in the latter. Descartes creates a theory of medicine outside of any practice of medicine, he proceeds from the normal to the pathological. Willis proceeds from the pathological to the normal. The distinction of these two viewpoints are familiar to him. In the preface to *Cerebri anatome* he employs, according to its modern acceptation, the term of Physiology which is habitually retraced to Haller, but which actually goes back to Fernel. However, the pathological muscular contractions, rigidity, spasms, cramps, clonus take on sometimes an amplitude and intensity, at others an appearance that is jerky, discontinuous, explosive that are not present in normal contractions (1). One will not be surprised hence to see Willis import, in the invention of his physiological principles, some aspects of the phenomena which he proposes to deduce as consequences.

The vigor of Willis in the enunciation of problems, his subtlety in the enumeration and the discussion of possible solutions do not make him unequal to Descartes. His anatomical vocabulary is rich and precise. Even though his principles of explanations of natural phenomena in general, and of biological phenomena especially, are borrowed from the chemistry of the time, Willis is not a mind less positive than Descartes, nor less concerned than him to only invoke forms of non transcendental causality.

(1) Descartes reports at least once the example of convulsions in support of the proposition that the machinery of the body is agitated by movements to which will cannot oppose itself. *Letter to Morus*, February 5th 1649, A.-T., V, p. 277 ; BRIDOUX, p. 1319.

Willis like Descartes seeks in techniques some relations of analogy capable to make intelligible the production of organic phenomena. But they are not the same techniques. Willis can be as mechanistic as Descartes but he is not a mechanist. The Cartesian mechanism² is the statics of Archimedes and the dynamism of Galileo, if not to the letter and the spirit, at least as for the object. The dynamism of Willis is a vague and distant presentiment of energetism. According to Galileo and Descartes, dynamism, is the theory of a canon ball's movement. Dynamism, according to Willis, is the theory of the deflagration of powder. "Assuredly, says Willis, it won't be difficult to reduce to the laws of mechanics the muscles, and moreover the activities of the whole kinetic function, and to explain them conforming to its rules (1)."

What distinguishes essentially Willis from Descartes, is the conception of the heart's movement and the circulation of blood which he borrows faithfully to Harvey; the concept of the nature of the animal spirits and their movements in the nerves; the conception of the nerves' structures; the concept of the mechanism of muscular contraction.

From
the
incorrect

According to Willis, just as Harvey, the heart is a muscle and nothing more than a muscle. If it is *primum movens* in relation to the other muscles, it is only through the rhythm of its function, but following an identity of structure. "It is not a noble viscera and first in the hierarchy, but a pure and simple muscle (2)." It is to the action of the spirits in the heart, as in any other muscle, that one must attribute the circulatory movement communicated to the blood, like by an hydraulic machine (3). However Willis distinguishes the circulation and the fermentation of blood,

(1) De Motu Musculari, in *Opera Omnia*, I, p. 674.

Italics

(2) *(Cor) enim non viscus nobile et princeps est ut usque adeo uti perhibetur set merus musculus, carne tantum et lentinibus more coeterorum constans, et sanguini circumpellendo inserviens. Pharmaceutices Rationalis (1673), section 6, chap. I. Cf. Appendix, p. 174. See also De sanguinis incalescentia (1670), Ibid., I, p. 663 : ex quo liquet cor esse merum musculus..., and De nervorum description et usus (1664), ibid., I, p. 368 : Dicendum erit quod ipsius cordis compages, carne valde fibrosa constans, potius nmusculus quam parenchyma appellari debet.*

(3) *In corde, sicut in toto praeterea muscoloso genere, spirituum insitorum particulis spirituosalinis copula sulphurea a sanguine suggesta adjungitur; quae materies, dum pisirtus agitantur, denuo elisa, ac velut explosa (non secus a pulveris pyrii particulae accensae ac rarefactae) musculus, sive cor ipsum, pro nru motivo efficiendo inflant ac intumesciunt, De Nervorum descriptio et usus, Op. Omnia, I, p. 368. — On the assimilation of the heart to a hydraulic machine : Circa motum sanguinis naturalem, non hic inquirimus de circulatione ejus, set quali cordis et vasorum structura velut in machina hydraulica constanti ritu circumgyretur... De Febribus (1659), Op. Omnia., I, p. 71.*

²trans. note : i.e., the corresponding philosophy (not the common sense).

a mechanical phenomenon and a chemical phenomenon. The fermentation is the source of the sanguine heat, but here it is the blood that gives to the heart its heat and not the heart to the blood (1). Circulation and fermentation are so well distinguished by Willis that he sees in the first a phenomenon common to all animals, while the caloric fermentation is only observed, according to him, in the higher/superior animals (2). Let's recognize to Willis a first merit, that of not having believed he needed, like Descartes, to correct Harvey on this fundamental point of anatomy and cardiac physiology, to not have ^{attributed} ~~related~~ to the heart, with regard to the muscles, a privileged role and an eminent nature.

As for the animal spirits, Willis holds them for blood that has been distilled, purified, sublimed, spiritualised. All these terms are by him and disposed as such in a series where the dignity of terms increases. It is in the brain and the cerebellum, functioning to the letter like stills/alembics (3), that the animal spirits are separated from the blood, and there only. These spirits have, along the nerves and the fibers, functional movements that alternate between flux and reflux, which is to say from the encephalon to the periphery — membranes, muscles and parenchyma — and reciprocally. But on the whole and over time, compared to gyratory movements of the heart, the course of spirits is an irrigation. Emanating from the encephalon, they dissipate at the periphery. There is on this no difference between Willis and Descartes. But we see that Willis separates the origin of the blood's movement and the origin of the spirits' movement, and that he admits two directions in the functional movement of the spirits in the nerves. And especially Willis sees in the animal spirits something very different than Descartes.

The direct and compared reading of Descartes and of Willis leads on to pose a problem of historical critique. How can it be that authors as serious and informed as Nordenskiöld, Radl, Fearing do not mark with more force that,

(1) *Calorem tamen cor omnino a sanguine et non sanguis a corde mutuatur. De sanguinis incallescencia, Ibid., I, p. 663.*

(2) *Ibid., I, p. 661.*

(3) *Cerebri anatome* (1664), chap. IX, X and XV, in *Op. Omnia*, I, p. 289 sq. and p. 320. In *De fermentatione, ibid., p. 4*, WILLIS gives the description of a still/alembic and explains its functioning. — In the hierarchical disposition of the terms distillation, purification, sublimation, spiritualisation, we find a particularly precise verification of the ideas of Mr. Bachelard : "The imagination is necessarily valuation... Let us address the alchemists. For them transmuting is perfecting... for an alchemist a distillation is a purification which elevates the substance by alleviating it of its impurities" (*L'air et les songes*, Paris, 1934, p. 296 and 298).

under the same traditional name of animal spirits, Willis has of that thing an idea almost without precedent? Nordenskiöld does not make any difference between the theories of Descartes and of Willis (1). Radl notes rapidly that the animal soul and the sensitive human soul are, according to Willis, of the nature of fire (2). Fearing notes, as rapidly, that Willis regards the spirits as an agile and elastic substance (3). Fulton is better advised by writing that "Willis reproduced, with some interesting modifications, however purely speculative, the Galenic notion of animal spirits" (4). Admittedly, there could be question, at that time, only of speculative modifications and Willis ignored, as everyone until the middle of the XVIIIth century, the remarkable (experiences) of the genius Swammerdam on muscular contraction (5). But they are purely speculative modifications that will enable Willis to formulate the concept of reflex movement.

→ experiments

According to Descartes, the spirits are bodies in motion, they are nothing in power, but only in act, they represent the quantities of movements that are added according to the laws of arithmetic, here like everywhere else outside of the animal body. Descartes does say of the spirits that they are fire and flame, but this fire is a subtle body and not a source of latent energy, and this flame is nothing but a term of comparison. The animal spirit, according to Willis, is a power that needs to be actualized. It is a spirit of surprises. Should only one ray of light appear and it goes to detonate. Its actualization is an explosion whose effects multiply the cause conforming to rules that are not those of arithmetic nor of geometry (6). According to Descartes, the spirits are expelled from the heart by the muscle in the fashion of

(1) *Op. cit.*, p. 152-153.

(2) *Op. cit.*, p. 159.

(3) *Op. cit.*, p. 55.

(4) *Op. cit.*, p. 17.

(5) Through the systematic study of the contraction of a frog's muscle excised, Swammerdam showed that the isolated muscle continued to respond to the excitation/stimulation of the nerve long after the interruption of the link with the spinal cord/~~base of the brain~~, and that the contraction was done without any change in volume. All of this was opposed to the explanation of the contraction by afflux of animal spirits in the muscle. But these works of Swammerdam (1637-1686) became known only in 1737-38 through the publication of the *Bybel der Natuure, Biblia Naturae*, in the Batavian language, with a Latin translation by D. GAUB, preceded by a preface from BOERHAAVE. An English translation was given of it in 1758. The works of Swammerdam on the frog are reported in a chapter entitled : *Experimenta circa particularem musculorum in rana motum, quae in genere ad omnes musculorum in hominibus aequae brutis motus adplicantur* (t. II, p. 835-860). See the excellent presentation of the works of Swammerdam on the muscle in FEARING, *op. cit.*, p. 41 sq.

(6) *De motu musculari* (1670), in *Op. Omnia*, I, p. 680-84. See appendix, p. 176-7.

a draft of air or a jet of water, according to Willis, they are propagated from the encephalon towards the muscle like heat or light, conveyed/transported and retained by a liquid succus filling the gaps of the intra-nervous structures, these spirits find on site, in the arterial blood that bathes the peripheral organs, a reinforcement of vivacity and motor power, through the adjunction/addition of nitro-sulfurous particles to the particles of the spirits of salts that enter in their composition. An ignition is thus produced by this fact and an explosion of the detonating mix, analogue to an explosion of canon powder. It is this intramuscular explosion which provokes the contraction and following the movement (1).

to legitimize

On this point, Willis is aware of innovating and even to disconcert his contemporaries. Thus the care that he takes in legitimizing the term of explosion, and to have admitted as wholly positive a type of mechanism that surpasses the usual machines (2). The machines of Descartes are the coin, the pulley, the lever and the winch (3); the automata whose analogy helps him to represent the animal machine are organs (4), the clock and the hydraulic marvels of the park of Saint-Germain-en-Laye (5). Willis uses also the comparison of the organism in motion to the play of organs, but it is the animal soul that Willis assimilates to organs of which the encephalon is the bellow (6),

(1) Cf. *supra*, p. 60, n. 3 and Appendix, p. 179. We find in *De fermentatione* all the elements of physics and chemistry preliminary to physiological explanation by WILLIS, and especially in chap. X; *De natura ignis et obiter de colore et luce: Ex praemissis non difficile erit pulveris pyrii in tormentis belicis usitati naturam explicare.*

(2) *Certe ob hanc rationem et cordis et caterorum musculorum virtus motiva robustior, et supra organum quodvis mechanicum, elastica evadit: nempe in quantum spiritus animales, ubique musculo genere agentes, sibimet copulam explosivam adsciscant.*

Quod si Explosionis vocabulum, in Philosophia ac Medicina adhuc insolitum, cuius minus arrideat, proinde ut Pathologia σαπασμώδης huic basi innitens, tantum ignoti per ignotius explicatio videatur: facile erit istiusmodi effectus circa res tum naturales tum artificiales instantias et exempla quam plurima proferre, ex quorum analogia motuum in corpore animato, tum regulariter, tum ἀνωμάλως, peractorum, rationes aptissimae desumuntur. (De morbis convulsivis, in *Op. Omnia.*, I, p. 439).

(3) Explanation of the engines, etc., in the *Letter to Huygens*, October 5th 1637, A.-T., I, p. 435; BRIDOUX, p. 973.

(4) *Traité de l'homme*, A.-T., XI, p. 165-166; BRIDOUX, p. 841-42.

(5) *Ibid.*, A.-T., XI, p. 130-131; BRIDOUX, p. 814-15. On the automata during the times of Descartes, cf. A.-T., XI, p. 212 and XII, p. 163 and p. 123. — We remind that F. COMMANDINUS, in 1583, had translated from Greek to Latin a text of Heron, containing the description of the mechanisms using the pneumatic and hydraulic force, under the title *Heronis Alexandrini Spirituum liber*. In 1588, Aug. RAMELLI, engineer of the king of France, had published a treatise *Le diverse et artificiose Machine*, where are found described, among others, hydraulic mechanism of singing birds.

(6) De anima brutorum, *Op. Omnia*, II, p. 45; Cerebri anatome, *Ibid.*, I, p. 336.

whereas for Descartes it is the body that is similar to an organ of which the heart would be the bellow. The terms of reference of his explanatory comparisons are, for Willis, most of the time, engines of fire : [air] lighter³, burning glass⁴, Greek fire⁵, canon and canon powder (*pulvis pyrius*, *pulvis tormentarius*) (1). We see well here which habits of thought, which imaginary themes in the end, distinguish Willis from Descartes. He is from the school of that Van Helmont for whom chemistry and pyrotechnics are but one, who created the word *gas* to designate that state of the matter whose subtlety has only impetuosity for equal, who committed to distinguishing inflammable gases from gas sylvestre (2) (carbonic anhydride CO²), who established — by interpreting correctly the experiment of the candle reignited by means of its fume — that the flame is not an element but a fume or a vapor that has been lit (3). Willis is also the contemporary of Robert Boyle (1627-1691) who suspected the presence in the air of a “vital substance” necessary for combustion, for respiration, for fermentation — which Lavoisier would identify in the oxygen — who utilized the vacuum pump of Otto von Guericke for experiments on the elasticity of air and on the combustion of canon powder in a vacuum⁶ (4). Such that when Willis conceives of the animal spirit as an inflammable substance, explosive and elastic, when he meditates [on] the effects of canon powder, by returning in his mind Van Helmont’s visions and Boyle’s experiments, it is on a science of non Cartesian inspiration that he seeks to found his biology. And, undoubtedly, Descartes does treat of the nature and the properties of canon powder in the *principes de la philosophie* (IV, art. 109-115), but it is as a mechanist not a chemist, because he seeks the explanation of the deflagration in the figures and the movements of the

(1) De motu musculari, *ibid.*, I, p. 680-8. Cf. Appendix, p. 187. — De morbis convulsivis, *ibid.*, p. 516-17.

(2) Sylvestre meaning savage/wild⁷. Gas is, for Van Helmont, an incoercible body, that one cannot neither enclose inside recipients, nor make sensible to the sight.

(3) From the wick of a candle, once we blow the flame, arises a column of fume. We can reignite the wick from a distance, by nearing an incandescent body to the fume. FARADAY has made this experiment both classic and popular in his *History of a candle*. Cf. L. BOURGOIN, *Histoire des sciences et de leurs applications*, I, Montréal, 1945, p. 234. — On the relations of chemistry and biology in Van Helmont, cf. RADL, *op. cit.*, p. 199-200.

(4) *New Experiments Physico-Mechanical touching the spring of air and its effects*, 1660. Cf. Douglas McKIE, *Fire and the flamma vitalis* : Boyle, Hooke, and Mayow in *Science Medicine and History, written in honour of Charles Signer*, vol. I, Oxford University Press, 1953, p. 469-488. — WILLIS cites Boyle, many times, in his treatise *De sanguinis accensione*.

³trans. note : briquet à air.

⁴trans. note : miroir ardent. (War) device associated with Archimedes.

⁵trans. note : a weapon.

⁶trans. note : dans le vide.

⁷trans. note : sauvage.

elements of the powder. We know his contempt for the principles of the chemists "that are nothing but a false imagination" (1), "words out of common usage" (2), capable of concealing ignorance under the appearance of knowledge. His aversion for chemistry is such that Descartes imports in his explanation of the deflagration of the powder the explanatory principles of the movements of the [canon] ball.

But it is not only a greater fidelity to the physiology of Harvey and a more chemical than mechanical conception of animal spirits that differentiate Willis from Descartes. Concerning the nerves, Willis does not admit, like Descartes, that their structure permits them to play a role different in the phenomena of sensitivity and organic motricity. According to him, the structure of the nerves is unique, they are fibrous and porous. They are neither tubes sheathing nets, nor plain stems. They admit vacuums, gaps, inside which the animal spirits can insinuate themselves. They are prolonged by the fibers which are not all their capillary prolonging, but of which some are born, independently and outside of them, through epigenesis. These fibers are like nerves traversed or inhabited by the spirits. Inside these nerves and these fibers, the spirits have movements of flux and reflux, undulatory movements. They travel alternatively a system of radiating ways from a center, the encephalon (3).

The anatomo-physiological conceptions that we have just exposed represent in their whole the necessary conditions permitting to Willis what was forbidden to Descartes in the solution of the problem that concerns us. But they are not yet sufficient conditions. The originality of Willis manifests better in the power of imagination that leads him to exploit up to their last consequences the explanatory comparisons that he utilizes. The nervous system being conceived, in its anatomical structure, as radiating rather than ramified, the encephalon splitting into nerves like the sun in rays, the propagation of the spirits is conceived as irradiation (4). And the

(1) *Letter to Mersenne*, July 16th 1640, A.-T., III, p. 130.

(2) *Letter to Newcastle*, November 23rd 1646, A.-T., IV, p. 517 ; BRIDOUX, p. 1252.

(3) On the anatomy and the physiology of the nerve, see *Cerebri anatome*, chap. XIX, and Appendix, p. 80 sq.

(4) *Cerebri anatome*, *Op. Omnia*, I, p. 336 : *Quippe spiritus animales a Cerebro et Cerebello, cum medullari utriusque appendice, velut a gemino luminari affluentes, Systema nervosum irradianz...* See Appendix, p. 180. - *Spirituum hanc radiationem a Cerebello alio ritu, ac alteram a Cerebro dimanare*. *Cerebri Anatome*, *ibid.*, chap. XVI, p. 321.

spirit itself whose essence could not be entirely explained through assimilation with any chemical matter, must, as it is born from the flame of the blood, be said to be similar to a light ray (1). This analogy is pursued to the end. The instantaneousness of the nervous discharge is assimilated to the transmission of light. There is nothing even the final act of the excitation/stimulation of the muscle by the nerve that does not sustain this comparison. Since it is needed, for the luminous corpuscles to illuminate, that they meet ethereal particles disseminated in the air, it is necessary for the spirits to be able to liberate the power of which they are charged that they meet the sulfurous or nitrous particles disseminated in the interstitial blood. The spasmodic intramuscular explosion makes the contraction. Thus the animal spirit is light awaiting to be fire. Its transport is on the order of the ignition and its effect on the order of the deflagration. The nerves are no more, in this physiology, cords or pipelines⁸, they are wicks (*funis ignarius*), Bickford fuses (2).

[f.n. reflected spirits]

Hence it is not surprising that, if one finds only once in Descartes' work the words "*esprits réfléchis*", one finds on the contrary in the work of Willis so often the words of reflection (*reflexio*) and of reflected movement or reflex (*motus reflexus*) that the census would be fastidious. We are not dealing here, as undoubtedly in Descartes, with a fugitive image or a circumstantial word, but with a concept, elaborated, arrested and to such a high degree explicit that, far from adhering to just one term, it constitutes the intellectual invariant of an astonishing variety of expressions and of metaphors. Because Willis conceives the double movement of centripetal and centrifuge propagation of the animal spirits not only after the image of light, but after the image of all phenomena susceptible of an inversion by reflection, in the images of the waves on the water's surface (3) just as after the image of sound and of echo (4). And it is logical, since having conserved the notion of a

(1) *Quapropter longe melius juxta hypothesim nostram, hos spiritus e sanguinis flamma emissos, lucis radiis, saltem iis aurae aërique intertextis, similes dicamus.* De Anima Brutorum, Op. Omnia, II, p. 31. *Spiritus animales, velut lucis radios, per totum systema nervosum diffundi supponimus.* Cerebri Anatome, *ibid.*, p. 338.

(2) *Pari fere modo ac si quisquam pulveris pyrii acervoe per funem ignarium ad distans accenderet.* Pharmaceutice rationalis, part II, *ibid.*, II, 149. Cf. also *De motu musculari*, *ibid.*, I, p. 681.

(3) *Quoties animae parte exteriori perculsa, sensibilis impressio, velut species optica, aut ianquam aquarum undulatio, interius ad corpora striata defertur.* Cerebri Anatome, Op. Omnia, I, p. 299.

(4) *Undulatio aeris concussi et moti quaedam excitata et prorsum tendens sicubi propter obicem quemdam ulterius recta deferri nequeat, statim reperiens, sive ad certos angulos reflecta...*, *ibid.*, p. 318.

⁸trans. note : canalisations.

intra-nervous succus that fixates and conveys/transportes the spirits, Willis feels bound to link in the same concept the direct and reflected movement of the spirits as such and the direct and reflected movement of the liquid in which they are momentarily incorporated. That is why we find in him so often the terms of direct and reflected undulation (*undulatio directa et inversa*), and multiple synonyms of the verb *reflectere*, namely *reciprocare*, *retorquere*, *refluere* (1).

We believe to have now reunited all the necessary and sufficient arguments to be able to affirm that it is Willis, and he truly the first, who was able to and who knew⁹ to form the concept of reflex movement conforming to all the logical requirements of such a formation. Its birth act is found in the *De motu musculari* (1670) from which we extract and translate the following text (2) :

"In all movement¹⁰, one must consider the following three aspects : firstly the origin of the action¹¹, that is to say the first indication of the movement to execute/perform, which always takes place in the brain or the cerebellum¹² ; secondly, the excitation, which is to say the transmission to the mobile parts of movements begun, the latter done inside the nerves by the motion¹³ of spirits which flow/flock¹⁴ there ; and thirdly the motor force itself, which is to say the manifestation of the spirits contained in the motor parts as a force of contraction or

(1) For the equation *reflectere* = *reciprocare* = *retorquere*, see *De morbia convulsivis*, *ibid.*, I, p. 486 ; for the equation *reflectere* = *refluere*, see *Cerebri anatome*, *ibid.*, I, p. 299.

(2) *De motu musculari* (*Excercitatio medico-physica*) in the appendix of the treatise *Affectuum quae dicuntur hystericarum et hypochondriacarum Pathologia spasmodica modica vindicata*, in *Opera Omnia*, Lyon, 1681, I, p. 673 : *In omni motu haec tria considerari debent scilicet primo actionis origo, sive prima motus obeundi designatio, quae semper fit in cerebro aut cerebello ; secundo ejus instinctus sive incoepti ad partes motivas transmissio, quae spiritum intra nervos scatentium commeatu perficitur ; ac tertio, ipse impetus motivus, seu spiritum partibus motricibus insitorum, in vim sive contractivam, sive exelasticam exertio. Ex hoc motuum species ac differentia deducuntur. Quoad motus originem seu principium annotamus quod iste qui a cerebro, appetitu conscio ac auspice procedit, spontaneus appellatur ; qui autem a cerebello, ubi lex naturae praesidet, excitari solet, cujusmodi sunt pulsus, respiratio, cum multis aliis, mere naturalis seu involontarius vocatur ; uterque horum vel est directus, qui ab hoc aut illo principio per dicam, intestina deliberatione hoc aut illud expetit, ac motus respectivos elicit ; pariter item quando justu solennem naturae ritum functionis naturalis ac vitalis munia ordinaria perficiuntur ; vel motus viriusque generis est reflexus, qui scilicet a sensione praevia tanquam causa evidenti aut occasione immediatius dependens, illico retorquetur ; ita blanda cutis titillatio ejus frictionem ciet, et praecordiarum aestus pulsum et respirationem intensiores accersit.*

We draw attention to the fact that, according to this text, Willis admits that the reflex action of the spirits can appear as well in the order of the spontaneous movement as well as in the order of the natural movement.

⁹trans. note : qui a pu et su.

¹⁰trans. note : *In omni motu...*

¹¹trans. note : *primo actionis origo...*

¹²trans. note : *quae semper fit in cerebro aut cerebello...*

¹³trans. note : déplacement. (We avoid using the term movement here)

¹⁴trans. note : affluent.

of expansion. From this triple source, following naturally that things happen differently in each of them, derive multiple species and varieties of movement. Concerning the origin of the movement or its starting point, we make the remark that which proceeds from the brain, with consciousness of appetite and initiative, is said spontaneous ; that which, on the other hand, is habitually excited from the cerebellum, where the law of nature reigns, species that count the pulse and the respiration among many others, is said purely natural or involuntary. The one and the other of these movements at times is direct, when from the one or the other origin, it is excited by itself and initially, like for example every time that an appetite seeks after some deliberation proper and so to say intestinal, to reach such or such thing, and provokes the corresponding movements, or else like when, conforming to the habitual manner of nature, the ordinary charges of natural and vital function are fulfilled. At times the movement of the one or of the other species is reflected, which is to say so far as immediately depending on an antecedent sensation as well as on a manifest cause or occasion, it is returned instantaneously towards its starting point. It is thus that a light titillating¹⁵ of the skin provokes scratching [of it] and that the inflammation of the precordial region commands a more rapid pulse and respiration."

We are here truly in the presence of a concept, as we do find its definition. This definition is both nominal and real. The terms *motus reflexus* are used to name a certain kind of movements of which a familiar example is given to us : the automatic reaction of scratching. Having a defined, we have also a defining, which is to say a proposition that fixates the meaning of the defined.¹⁶ We have the word that fixates the adequation of the defining to the defined (*scilicet*). This definition is done in a few words, it is not a developed theory, it is an abstract. This definition is operated by division, as it is put in relation with a previous definition, that of the direct movement, which covers together with it the whole field of possible hypotheses concerning the origin of movement. Through reference to this clearly posed principle (*quoad motus originem seu principium*) the division is exhaustive : all movement has its origin, either in the center, or in the periphery. This biological definition leans by transposing it, on a definition from physics and even from geometry. In summary, concerning the reflex, ~~we find in nous trouvons chez~~ Willis the thing, the word and the notion. The thing, in the form of a general observation, a cutaneous reflex of

¹⁵trans. note : C. opted for chatouillement to translate *titillatio*.

¹⁶trans. note : défini and définissant.

the cerebro-spinal system, the scratch reflex ; the word, having become classic although improper (1), as adjective and substantive ; the notion, that is to say the possibility of a judgment in the initial form of a discernment or of a classification, under the eventual form of an interpretative principle of the experiment.

All the facts of anatomy and physiology used by Willis, all the hypotheses concerning the nature and the nervous influx converge systematically towards the notion of reflex movement. Little could matter to us that during his epoch, the theories of Willis were, as to their letter, less modern or fertile than the theories of Descartes. In matters of the history of sciences, the first duty is to recognize as father he who effectively is, even if another is judged more dignified / worthy to have been. And besides we will need to ask ourselves if the theories of Willis are in themselves and for us less modern than the Cartesian theories. We think, in any case, that the passage quoted from the *De motu musculari* seems to merit, as much as the passages from the *Treatise of Man* and the *Treatise of passions* where Descartes describes the cutaneous plantar reflex, the pupillary reflex and the palpebral reflex, the same justified celebrity, be it only because Willis chose to illustrate his definition of the reflex the example to which the works of Sherrington have conferred / given a typical signification, from the scientific viewpoint and the pedagogical viewpoint (2).

We see now why we it is not possible for us to subscribe in its entirety to the judgment of Fearing on the merits of Willis : "Willis is more precise, from the point of view of anatomy,

(1) "We designate under the name of reflex movement the movement due to a nervous excito-motor force whose manifestation is determined by the unconscious functional activity of the sensitive nerves. It would be more correct to call them movements determined by a nervous reflex action, because it is not the movement whose direction changes, it is the nervous force, on which depends the [bringing into] play of muscular contraction, that we consider in some sort to have been reflected inside the organism, such as to become centrifuge after having been centripetal ; but the first of these expressions is convenient and its employ consecrated by usage." H. MILNE-EDWARDS, *Leçons sur la physiologie comparée de l'homme et des animaux*, t. XIII, Paris, 1878-79, p. 112.

(2) The example of the scratch reflex reported in the text of the *De motu musculari* is not isolated, we find it again in *Cerebri Anatome, Op. Omnia*, I, p. 299 : *Enimvero sensibilis impressio corpora striata feriens, non raro, cerebro nullatenus affecto, cum reciproca spirituum animalium tendentia, motus locales retorqueri facit ; ita in somno (appetitu haud conscio) ubi dotor urget, illico manu admota locum fricamus.*

On the "scratch-reflex"¹⁷ in the work of SHERRINGTON, cf. *The integrative action of the nervous system*, London, 1906, p. 45-65 and 120-128.

¹⁷trans. note . [in English in the original]

and he opens the way to experimentation. The fact that he still remains faithful to a theory of the animal spirits similar to that of Descartes should not conceal the importance of his effort to account for the integrated and coordinated muscular action (1). We think on the contrary that if Willis, incontestably superior as an anatomist to Descartes, defends, in matters of neuro-muscular physiology, a conception in some sense as purely speculative, it is on the contrary wholly different in the letter and in the spirit, and that, if he forms the concept of reflex movement which will rid itself in the course of the XVIIIth century of an increasing weight of observations before finding in the physiologists of the XIXth century an explicit systematic experimental consolidation, it is based on a theory – no matter here if its called chimeric or even only philosophic⁸¹ of the animal soul that Descartes did not have. And in the same way that in the preceding chapter we have used the neuro-muscular physiology of the Italian iatromechanics as a counter-argument¹⁸, we intend here still to us, in matters of the history of scientific ideas, this kind of proof by means of the negative and even more exactly by means of the difference, the only besides permitted in such occurrence. We have in fact the luck to have in the person of William Croone (1633-1684), contemporary of Willis, a biologist who, like Willis, ranks among the chemists, who, like him, do not admit the Cartesian theory of the structure of the nerve and of muscular contraction, but who are missing the theoretical audacity and the quasi poetical intuition of sources and of principles of the vital movement. The testimony text to which we allude to is the *De ratione motus musculorum* (1664) (2).

Croone, announcing his intention to refute Descartes and claiming his place among the chemists whose theories he presents, affirms at the same time his intention to treat of the living as a machine (3). He cannot subscribe to the

(1) *Op. cit.*, p. 58.

(2) CROONE : doctor of medicine at Cambridge in 1662 ; member of the Royal Society in 1663 ; correspondent of Steno whom he met in Paris in 1665 ; founder of the *Croonian Lectures*, that is to say of conferences held at the Royal Society dedicated to the problem of muscular action. Cf. *infra*, p. 89, and FEARING. *op. cit.*, p. 65. We have read Croone's treatise in t. I of the *Opera Omnia* of WILLIS (Lyon, 1681) where it is found interpolated between the *Cerebri anatome* and the *De morbis convulsivis*, at pages 417-434. It is this text that we mean in our references.

(3) *Animantis corpus nihil nisi machinam quandam aut αὐτόματον esse*, *op. cit.*, p. 425.

¹⁸trans. note : cf. page 48 and following.

Cartesian assimilation of the contracted muscles to sails swollen by the wind (1). The nerves are not tubes, like Descartes thought, but funiculi and filaments enclosed in a membrane (2). Concerning the animal spirits, Croone admits their circulation, ~~la difference~~ different from Descartes and from Willis, and conforming to the theory of Glisson which he cites favorably (3). The spirits coming to the muscles through the nerves return to the heart through the veins. These spirits act in the muscles by chemical fermentation (4). By this we see that, just like Willis, Croone objects/opposes to Descartes certain details of muscular and nervous anatomy and the general principles of explanation of organic phenomena, chemistry against mechanics. Consequently,

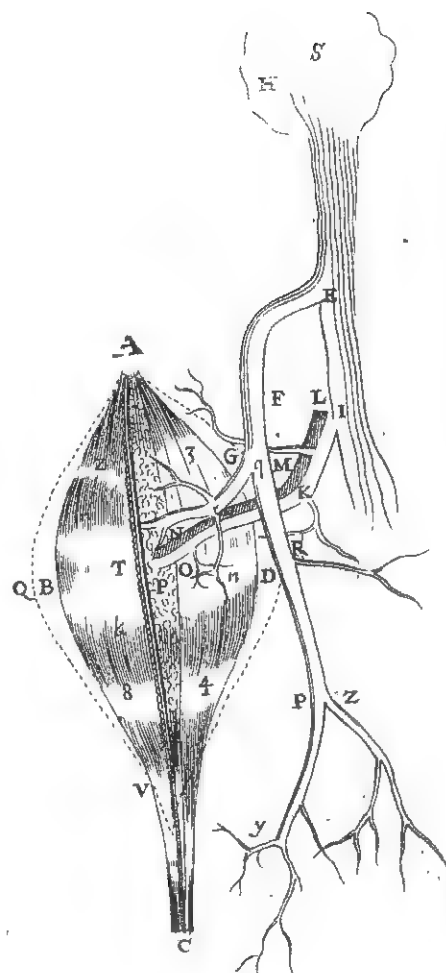


FIG. IV. — Figure schema of the muscular contraction in W. CROONE, *De Ratione motus musculorum* (in WILLIS, *Opera omnia*, I, p. 434, Lyon, 1681)

Hqn and SqPy : nervous fibers;
 ABCD : muscle;
 IKO : arteries;
 LMN : vein;
 A : fixed insertion of the muscle ABCD;
 C : mobile tendon.

(1) *Neque ipsum (musculum) spiritibus e nervo exiguo quasi flatu quodam ita distendi posse, neque adeo quicquam cum veto commune advertemus, op. cit., p. 418.*

(2) *Nervum... non autem tubulorum ritu excavatum, ibid., p. 420.*

(3) *Ibid., p. 420 and 428.*

(4) *Ibid.*

if Willis who is not, in the eyes of a physiologist of today, more authentically savant / scientist than Croone, succeeds in overtaking / overcoming him in the critique of Cartesian theories and in the invention of a concept bound to have some future in the explanation of muscular movement, it is due to the power of analogy. Life in so far as it is movement, *impetus*, effort against inertia, is related, according to Willis, to light ; and that is why it seems obvious to him that we find in the laws of light an archetype of the laws of life.

[...]

There is on the other hand a part of Fearing's judgments relating to the work of Willis which we must follow. It is true Willis is far ahead of his contemporaries in terms of the precision of the anatomical localization that he assigns to the functions of the nervous system and that he, the first, distinguishes clearly the seat of voluntary movement and involuntary movement, the functions of the brain and the cerebellum (1). The text of *De motu musculari* previously cited enables situating Willis in the history of ideas on the muscular movement that we sketch from Aristotle [onward]. We saw how Descartes refused to hold the soul responsible for ~~all~~ all the animal movements and admits, like Fernel, the independence relative to reason and to appetite of the motor function. This is what constitutes the Cartesian mechanism first. Galen separated natural movement — that of the pulse for example — commanded by the heart, the involuntary movement, commanded by the brain, seat of the soul, and he linked certain involuntary movements — that of the respiration for example — to an unconscious voluntary movement. Descartes, we could say, naturalizes the voluntary movement by subordinating the action of the soul to the anatomical and functional integrity of a motor mechanism which can do without it and whose principal spring is the heart. Willis, on the contrary, has made of the involuntary movement itself a kind of animation. Because, different from Galen, he admits the encephalic origin of all movements without exception. But by distinguishing, for the first time, with the greatest clarity, the functions of the brain and those of the cerebellum, he distinguishes also two souls that are the principle of each of the two sorts of movements : spontaneous or voluntary movements, commanded by the cerebral soul, and natural or involuntary movements, commanded by the cerebellar soul. Willis thus admits the existence of a spiritual soul (sensitive and reasonable) and of a corporeal soul (sensitive and vital) common

(1) *Op. cit.*, p. 56.

to Man and higher/superior animals (*anima brutorum*) (1). The impressions that exterior objects communicate to the organs of the senses are transported by the spirits towards the *sensorium commune*, of which the striae bodies are the seat, and can, if they get through, through the callous body, up to the cerebral cortex, bring on / create a perception, to which succeeds the imagination and memory. But the reflection of a part of the spirits in the region of the striae bodies explains the simultaneous production of a movement inside the members, movement tuned to the opportunity or the inportunity of the exterior object (2). It is thus to explain the automatic movements, eventually accompanied by the consciousness of their execution that Willis admits, we saw, the reflex movements as a species inside each kind of movement : spontaneous, which is to say controlled by the brain, and natural, which is to say controlled by ^{the} cerebellum. If we understand by animism the explanation of organic movements by a unique and omnipotent soul — which will expressly become the theory of Stahl later on — Willis is not, properly speaking, animist. He is, to dare such a barbarism, bi-animist. And one is free to say that he is more or less animist than a coherent animist like Stahl, depending on whether in the expression of corporeal soul one is more sensitive to the term of soul or to the term of corporeal. It is certain, in any case, that the theory according to which the superior and inferior centers of the encephalon (brain and cerebellum) presided over the voluntary and involuntary actions should, as noted very rightly / justly by Fearing (3), open as soon as the end of the XVIIth century, a fertile field for a type of experimentation hitherto practiced in episodic and grossly approximated fashion, namely the systematic destruction operated in successive stages of certain zones of the central nervous system. These experiments were to be held on organisms whose regulation by the nervous system is less strict than in mammals and correlatively more resistant to experimental trauma (amphibians, reptiles, birds). The physiological analysis of the functions was to find its objects of predilection in the field of comparative anatomy. Yet on this point again, the works of Willis indicated

(1) *Anima corporea, brutis perfectioribus et homini communis, cum toti corpore organico extenditur, et singulas, tum partes ejus, tum humores, vivificat, et irradiat.* De Anima brutorum, *Op. Omnia*, II, p. 28. — Descartes attributes, he also, to animals a corporeal soul (*anima corporea*) but its principle of movement is strictly mechanic. Cf. *Letter to Morus*, A.-T., V, p. 276 ; BRIDOUX, p. 1318.

(2) De Anima brutorum, *Op. Omnia*, II, p. 48.

(3) *Op. cit.*, p. 59.

future ways, since, faithful here still to the teaching of Harvey, Willis studied the structure and the function of the encephalon not only in humans, but in other mammals and in the birds, in accordance with a plan of study and a heuristic declaration of intentions exposed in the first pages of *Cerebri anatome*. The difference with Descartes is, once more, notable. On one side, the Cartesian theory of automatic movement concerns the intact organism. On the other, Descartes treats univocally of the structures of beasts and Man, structures "which are about the same in them as in us" (1). Finally the animal studied by Descartes is not any definite animal, but "the animal in general" (2).

We do not intend to promise of Willis more than he would know to keep. Careful to weigh the titles of Descartes against the reputation attributed to him as a precursor or leader, we are bound to guarding ourselves against the temptation of overestimating the importance of Willis. We do not forget the warning of P. Valéry : "I do not care much about those sorts of scientific prophecies, always suspect ; too many people think that the ancients invented everything. Besides, a theory only holds by its logical and experimental developments (3)." We will work towards establishing, in the following chapters, of which logical and experimental developments, here-above announced, the theories of Willis turned out to be effectively capable. Having shown that Willis invented the word and the concept of reflex movement in the context of a theory more imaginary than experimental, of nervous influx and of muscular contract^{ion}, remains for us, for the time being, to ask ourselves if this theory is nothing more than old hodgepodge left over in books, a curiosity for the erudite, or if it does indeed contain, in spite of its antiquated animism, and just like the Cartesian mechanism that certain biologists still claim, but in its own way, a sense for the phenomena of life that the minds of today can maybe if not adapt at least understand.

If we were ever so adventurous as to produce an edition of the *De motu musculari* of Willis, we would insert as an epigraph, to mark its spirit, some lines of Bergson : "If we search how a

(1) *La description du corps humain*, A.-T., XI, p. 226. See also *Letter to Morus*, , A.-T., V, p. 277 ; BRIDOUX, p. 1319.

(2) *Letter to Elisabeth*, January 31st 1648, A.-T., V, p. 112 ; BRIDOUX, p. 1294. See also *Description du corps humain*, A.-T., XI, p. 253.

(3) Introduction à la méthode de Leonard de Vinci (1894), in *Variété*, 33rd ed., p. 261.

living body goes about executing movements, we find that its method is always the same. It consists in utilizing certain substances that we could call explosive and which, similar to canon powder, are only waiting for a spark to detonate... When it executes a movement, it is that it liberates energy hence imprisoned ; it has only, for that, to touch a click, to brush against the trigger of a gun without rubbing, to call [on] the spark : the explosive detonates, and in the direction chosen, the movement is accomplished (1).” Let’s add that the many passages where Bergson, using the acquisitions of modern energetics, shows how the entire energy accumulated by the animal muscles has for origin, indirectly, solar light could pass, without too much effort, for a rejuvenation, scientifically authorized if not guaranteed, of the poetic analogies of Willis relating the latent energy of the animal spirits to cosmic light (2).

We would nonetheless admit, before / in front of the supercilious physiologists, that we grant ourselves the better role by detecting in a philosopher of the XXth century an avatar of a physiological theory from the XVIIth century. Scientists are fairly keen to think, in general, that philosophers nourish themselves with expired / out-of-date scientific doctrines. That is why we would prefer to call upon better accredited authors, by asking W. James to serve as intermediary between Bergson and them. “Our organism has accumulated energy reserves of which it usually does not make use of, but which ^{can} be useful on occasion ; they are like increasingly deeper layers of combustible or explosive materials that are piled in a discontinuous manner but ready to be employed by anyone who can jump down to reach them.” This text, gotten from the study *The energies of man* (1906), is cited by Spearman in *Les aptitudes de l’homme*⁵ (3), on the occasion of a summary of the theories of energetics concerning (the) nervous action (4). Since the Aristotelian conception of the *energeia*, the moderns have conceived energy as a psychological or physiological phenomenon ; and in that latter case, the laws of conservation, of distribution and of efficiency of energy require the assimilation of physiological energy and the energy

(1) La conscience et la vie (1911), in *L’énergie spirituelle*, 23rd ed., 1940, p. 14.

(2) Cf. *L’évolution créatrice*, chap. III : “De la signification de la vie.”

(3) 1st ed., 1926, 2nd. ed., 1932, Macmillan, London. Fr. trans. of the 2nd ed., 1936, published by *Le travail humain*, Conservatoire national des Arts et Métiers, Paris (edited since by the P.U.F.). The text of James is cited p. 105.

(4) *Ibid.*, chap. IX, p. 92-105.

⁵[t.n. The aptitudes of Man]

produced or utilized by the machines. Yet examining the arguments invoked against his own theory of nervous energy Spearman writes : "One of them is that all transfer of energy is in formal opposition with what we know about the nature of the process of the excitation/stimulation of nerves since each neuron acts like a charge of powder, separate, producing and consuming its own energy on site/at rest⁶... (1)" To this objection, Spearman objects in turn that in no way has it been proven that neurons are independent one from the others like juxtaposed charges of powder and adds, taking up again / renewing the opinion of A. V. Hill, that in matters of energy comparisons aren't reason. Since we do not seek to show that the theories of Willis are true, but only that some of his explanatory assimilations have still kept some current relevance, we can abstain from taking sides in this discussion. We insist however on noting a physiologist cited multiple times favorably by Spearman, we are talking about W. M. Bayliss, has taken up again in his *Principles of general physiology* (1915), an explanatory analogy, first proposed by Keith Lucas, and to this day used in physiological treatises, especially in that of L. C. Soula. We can explain, says Bayliss, the propagation of the influx, either in a purely physical manner in the fashion of the propagation of sound wave or an electrical current along a cable, or in a chemical manner, in the fashion of the combustion along a trail of powder (*such as a train of gun powder* [in English in the original]). Some of the experiments of Adrian, in which a nerve is anesthetized in one of its parts, show that the intensity of the influx, momentarily diminished in its anesthetized part, recovers beyond it its initial value. This fact seems to cut the deal in favor of the theory following which the nerve actively intervenes in the propagation of the influx by recreating from close to close the energy that a slice transmits to a neighbor in constant quantity, like a pinch of powder to another (2). When

(1) *Ibid.*, p. 312.

(2) *Principles of General Physiology*, Longmans & Green, London, 1915, p. 397.

Here the summary of the theory by SOULA : "The classic comparison with the propagation of a trail of powder gives an idea of what happens in the propagation of the influx. As soon as the powder has been lit at one of its extremities, the combustion propagates from close to close. In the same manner in the nerve, a region's activity triggers that of the neighbor[ing] region, which presents an identical reaction. If the powder is humid in a certain zone, at this level the combustion is less violent. As soon as the zone is crossed, the combustion resumes, it is only function of the local conditions. The same goes for the anesthetized zone of the nerve." *Précis de physiologie*, 2nd ed., 1953, Masson, Paris, p. 824.

⁶trans note : sur place.

Willis imagined the muscular contraction like an explosion of canon powder (*pulvis pyrius*) lit by the nerve functioning like an igniter [boute-feu] (*funis ignoriis*) he said thus, with respect to the chemistry of the time, all that he could, very reasonably.

We remind lastly that the conceptions of Pierre Janet on the reflex movement. Different from suspensive acts that in which consist the perceptive behaviors, the reflexes are "explosive acts", obeying to the law of all or nothing (1). And developing the meaning included in this term of explosive, P. Janet writes : "The reflex, once triggered cannot be stopped, nor modified in its direction, it cannot adapt to movements, to changes in the offensive causes. An individual who fires a shot of a rifle at a bird will not hit it if they do not take into accounts the bird's movements ; the reflex resembles that gun shot, it is a bomb that explodes immediately without being preoccupied with changes that take place during the burst (2)." This can, at a push, pass for an image, but if Janet thinks he can use it in 1926, why is it that we should find ridicule an analogue image in Willis in 1670?

It seems possible now to have admitted, based on the example of Willis, that one could be, in the XVIIth century, a doctor that was non-mechanist without being a crazy mystical or a driveller and that it is conforming to scientific truth and the meaning of history to look for valuable pressentiments in the work of Willis as in that of Descartes, in order to compare the ones to the others.

We should thus conclude by remarking that the idea of an involuntary movement explicitly named reflected and conceived as such presents, in the physiology of Willis, the following similarities and differences with the Cartesian idea of involuntary movement :

1° Willis' theory is no less deterministic than that of Descartes, its bases are the existence of a chemical determinism of the functions of the nerve and of the muscle ;

2° If the point of reflection of the influx of the spirits is still situated "[up] above", the distinction of the functions of the brain and of the cerebellum constitutes the first attempt to negate the cerebral privilege, in matters of sensory-motricity ;

3° The reflected movement as it is conceived by Willis is really the manifestation at the periphery, that is to say in the muscle,

(1) *De l'angoisse à l'extase*, I, 1926, p. 212-214. — *Les débuts de l'intelligence*, 1935, p. 35-42.

(2) *Les débuts de l'intelligence*, p. 44.

of an energy transported or propagated coming from the periphery, that is to say the organs of the senses (1) ; it is not the peripheral effect of a central motor, with central commands activated from the periphery, like in Descartes.

If Descartes has made, as we saw, some steps on the road that would lead to the concept of reflex, Willis knew, as for himself, how to make all the steps.

(1) *Enimvero ab initio fere omnis corporis animati motus ab exterioris objecti contactu ci-
etur ; nempe spiritus animales intra organum resides, ab objecto perculsi introsum impelluntur,
adeoque sensationem (uti dictum est) constituunt ; dein veluti cum fluctus litoris oram allidens,
denuo reperiuntur. ita in quantum ista spiritum ῥοπή interius vergens, partim a communi
sensorio reflexa, denuo exhorsum dirigitur, partim que interius usque in cerebri penetralia ex-
porrigitur, statim sensationi motus localis succedit...* De Anima brutorum, *Op. omnia*, II, p. 48.
Compare with this passage by a contemporary physiologist : "The denomination of reflex act
applied to the sensitivo-motor mechanism contains the notion of a form of energy exterior to
the living being, acting on ~~him~~ and returned (reflected) by the living being in the species of a
new energy." L. C. SOULA, *op. cit.*, p. 751.

them

CHAPTER FOUR

THE IGNEOUS SOUL [THE FIERY SOUL]

At the beginning of his *Discours sur l'anatomie du cerveau* (1665) [t.n. Discourse on the anatomy of the brain], Steno, making "sincere and public confession" of his ignorance as to the structure and the functions of the white substance and of the ventricles, adds : "We see even less certainty on the subject of the animal spirits. Is it the blood? Could it be a special substance separated from the chyle in the glands of the mesentery? Aren't the serosity its sources? There are some who compare them to the spirit of wine, and one could ask oneself if they aren't the matters of light themselves." Does Steno here aim explicitly and solely at Willis? It is certain in any case, that he also aims at him, being well aware of the explanation of the muscular contraction by a phenomenon of explosion, conception which he discusses and criticizes in the *Elementorum myologiae specimen* (1667) (1). When we insisted, in the preceding chapter, on the essential difference between the animal spirits according to Descartes and according to Willis, we said of the latter that he made of it an idea almost without precedent. Now justifying our reservation, we must indicate in the person of Gassendi an author, other than Willis, who holds the animal soul for consubstantial⁷ with light and fire.

In a chapter of his *Physics*, "Quid sit anima brutorum?" (2), Gassendi seeks to found, with the aim of exploiting it for his benefit, the theory of the igneous soul⁸ on the continuity of a philosophical tradition whose sources are Plato, Aristotle and the Stoics.

(1) *Opera philosophica*, II, p. 5.

(2) *Syntagmatis Philosophici Partis secundae seu Physicae sectionis tertias Mebrum posterius : De Rebus terrenis viventibus seu de animalibus, liber tertius : De anima*, ch. III, in *Opera omnia*, II, Lyon, Anisson & Devenet, 1658.

⁷trans. note : i.e., of same substance, nature...

⁸trans. note : l'âme ignée. In the *Encyclopedie*, ignée has the following definition : "... (Phyl.) qui appartient au feu. (...) Voyez FEU & CHALEUR" / philosophy, that which belongs/relates to fire, see entries fire and heat. Vol. 8, p. 548. The location of the article merits further commentary : located between ignare and ignicole, between the ignorant and the adorer of fire, i.e. ignorance and the love of fire.

*trans. note : It is the section ~~that begins~~ pp 61-62 F. that begins "..." under 79 the same traditional, ...

It is that the flame and the fire appear to him as principles fit to conciliate paradoxically the existence of an animal soul and the explanation of its power, in the general spirit of a corpuscular and strictly materialist physics. The transition seems easy between the flame, light and the soul, on the condition to raise to the absolute, in some sort, the result of two confused operations, division and purification. Therefrom this assimilation : *Imo et ad usque ipsam lucem quam suo loco deduximus nihil aliud esse quam flammulam, seu avolante tenuissiman, ac purissiman flammae partem. Cum id, inquam, ita se habeat nihil vetare quin Anima talis ignis sit* (1). It is to La Fontaine that we shall ask a free but faithful translation of this text, in an anti-Cartesian context (*Les deux rats, le renard et l'oeuf*, 1679) :

*I would spirit away a piece of matter,
That one could no longer conceive without effort,
Quintessence of the atom, extract of light,
I do not know what more vivid and more mobile still
Than fire ; for finally, if the wood makes the flame
The flame, by purifying, cannot it not of the soul
Give us some idea?...*

But it is not only for the conciliation of his psychology and of his physics that Gassendi focuses on the theory of the igneous soul, it is also because of the positive character of the explanation it enables of the disconcerting disproportion between the impalpable nature of the soul and its power of mobilization of the body's mass, a disproportion that is singularly astonishing in the case of the elephant : *Mirum sane dictu, corpus Elephantis tanti ponderis ita moveri, sustentarique a tam mire tenui substantiola...* (2). But the forces of fire are considerable, as we can see in the example of the canon powder whose deflagration has the double effect of projecting, at great speed, a weighty [canon] ball and to imprint a recoil on the culverin⁹.

Gassendi however is very far from deriving from this assimilation of the animal soul to the flame the same consequences as Willis in matters of physiology and pathology. Indeed, in a posterior chapter *De vi motrice et motionibus animalium* (3), he shows himself faithful to the Aristotelian and Cartesian principles in his description and explanation of the animal movements of

(1) *Op. cit.*, p. 251.

(2) *Ibid.*, p. 250.

(3) *Op. cit.*, liber XI.

⁹trans. note : (another) old weapon, canon.

locomotion, assimilating their members, their bones, muscles and tendons, to pieces of a siege or lifting machine, but without ever converting the theory of the igneous soul into an original explanation of muscular contraction. When thus Willis, in two or three occurrences, cites Gassendi and refers to him (1), it is less because he insists on recognizing a debt than to establish some authority in favor of a theory of which he is aware, as we saw, that it must appear new / unheard of and strange/unusual/unique to his contemporaries. In sum, Gassendi renders to our subject matter of grasping the originality of the contribution due to Willis, in neuro-muscular physiology, an inverse service to that rendered by Croone. *The latter, if he had the positive mind of a doctor, The former, lacked the genius of imagination and analogy, if he has the theoretical audacity of a philosopher, fails to return to the cavern of the animal organism. Willis allies an intuitive sense of biological energetics and the power of exploitation of the relations glimpsed to the perspicacity of a clinician and the pondering of an anatomist.

However most of Willis' readers, in the XVIIth and the XVIIIth century, have been more sensitive to the spirit of the animist tradition from which he borrowed some principles than to the character, in a sense revolutionary, of the consequences he drew [from it] for the explanation of the phenomena of movement. The theory of the igneous soul won in interest over the chemistry of the contraction. In particular, there is one philosopher who, having thought he could draw from the reading of the ancients, and notably Plato, the elements of an ontology whose principle is ~~the~~ the Fire or Ether, has found in the treatises of Willis some direct arguments in favor of his theory. Meant is Berkeley (1665-1753) whose *Siris* (1744) (2) enlarges to the dimension of a metaphysical system the considerations on the nature and the therapeutic virtues of tar water. Through Berkeley, and in the person of Willis, the history of biology cuts, once more, across the history of philosophy, for the reason undoubtedly that here, as in so many other cases, biology returns/restores to philosophy what it had gotten from it in another form. If Berkeley was able to take in the *De sanguinis accensione* [some] arguments in favor of the theory of the igneous soul, it is because Willis had already incorporated this metaphysics to this physiology.

(1) Especially in *De Anima Brutorum*, 1st Part, chap. I in fine and chap. VII.

(2) *Siris, Chaîne de réflexions et recherches philosophiques concernant les vertus de l'eau de goudron*. *French translation by G. BEAULAVON and D. PARODI, "Les classiques de la Philosophie" collection, Paris, A. Colin, 1920.

* trans note: as a reminder, pp 70f.
 * trans. note: - indicate the English title

We do not undertake to summarize here *Siris*, the reading of which does not present any major difficulty where specifically the many references to Aristotelian, Stoic and Neo-Platonic doctrines are concerned. We will only note that Berkeley, as happens so very often to those who report on some tradition that they attach themselves to, are attached to, includes all of its becoming in the origin and shines a light on its beginning from its becoming as much as he derives the sequel from the start. When Berkeley writes : "In the *Timeus*, Plato supposes that there is something like a network of fire and rays of fire in the human body. Does this not seem to signify the animal spirit, which flows, or rather springs forth, through the nerves?" (§ 166), we are in the right to ask ourselves if this is not a Plato red through [the lens of] Willis? Because it is Willis who speaks of the nervous system as a concretion of rays around the encephalon, of the irradiation of the nervous system by the spirits, and of the gush of the spirits in the nerves (*spiritus animales per nervos scaturientes*).

Like Willis, Berkeley sees in the animal spirits (§§ 171, 178, 280) the "luciform vehicle"¹⁰¹¹ of the soul's motor force. Like Willis, Berkeley is struck by the expansive, violent and destructive power of fire : "Such is the rarefying and expansive force of this element that it can produce in an instant the greatest and most surprising effects..." (§ 170). When Berkeley refutes the opinion according to which the pure and homogeneous ether is supposed to be the unique cause of muscular movement, by the impulsion that from the brain and through the nerves it supposedly impresses on the imprisoned ether in the fleshy fibers, he separates from Newton (§§ 200, 224) and when he affirms that it is an heterogeneous mix/melange of fire and air that is the principle of movement (§§ 197, 198, 229), it is an opinion in part similar to that of Willis that he adopts. One should thus not be surprised to see Berkeley rallying to the theory of Willis concerning the nature of the animal spirits and their relation to the animal soul : "The real existence of some thing like the vital flame, igniting, sustaining and extinguishing effectively like the common flame and by the same means, is a theory professed by some modern, especially by the Dr Willis, in his treatise *De sanguinis accensione*... Such is the conception of Dr Willis ; and perhaps does it enclose some truth, so long as one understands that this light or fire can really constitute an animal spirit or the immediate vehicle of the soul" (§ 205). If a further testimony were needed on the non-Cartesian significance

¹⁰trans. note : We went through the articles : § 171 does contain the expression in the context : "This tunicle of the foul, whether it be called pure aether, or luciform vehicle, or animal spirit seemeth to be that which moves and acts upon the grofs organs (...)".

¹¹In The Oxford English Dictionary, luciform : "having the character of light (...) applied spec. to the 'vehicle' of the soul imagined by the Neo-Platonists". Vol. 6, p. 486. Betw. lucific ("light-producing") and lucifrian returning to luciferian...

schema of mechanistic type (altern.)

during the period considered, of the theory of the igneous soul, one could find it in Berkeley (§§ 232, 233, 239, 249). We should thus not be astonished to see him attribute as cause to these same automatic movements, for the explanation of which Descartes had attempted mechanistic type schema, the action of an Active Intelligence, "that very same perhaps which directs the bees and spiders and which moves the members of people walk^{ing} while sleeping" (§ 257).

We just saw Berkeley oppose Newton to follow Willis on the explanation of muscular contraction. Inversely, Haller links Newton and Willis. In the *Elementa physiologiae* (1), Haller dedicates long developments to various proposed "conjectures" in order to give an account of the mechanism of nervous influx and the functions of the animal spirits. He distinguishes those that assimilate the spirits to light (*lux, lumen*) and those that assimilate them to the flame or the fire (*flamma, ignis*) : he ranks Willis among the former (2) and Descartes among the latter. According to Haller the explanation of muscular movement by Willis and the explanation of the same phenomenon by Newton are very close, because different from Berkeley, he neglects the chemical nature of the animal spirits as Willis conceives them in order to retain but their only physical, luminous nature. It is exact that Newton, in the *Mathematical principles of natural philosophy* (1687) (3) as in *Opticks* (1704) (4), explains the visual sensation and the movements it determines by the propagation, along the optical nerve and the motor nerve collected by the brain, of the vibrations of the ether, universal fluid, at once elastic and capable of integral penetration of the whole body, of which we know that he holds it for corporeal and for spiritual, for the authentic *Sensorium* of God, instrument of the divine omnipresence and omnipotence in all points of space. The notion of spirit is for Newton, as for the chemists, the notion of an immaterial matter, of a subtlety at once physical and psychic. Through it, Newton is attached to the philosophical tradition that is ante and anti-Cartesian.

and
scientific

How to explain the divergence of the opinions of Berkeley and of Haller on the planes of the explanations provided by Willis and by Newton? As for Haller, he is, like most of the savants/scholars/scientists

(1) T. IV, *Cerebrum, Nervi, Musculi*, book X, section 8, Lausanne, 1766.

(2) *Lucis naturae similes [spiritus] finxerat Willisius, ex sanguine in vapore resoluti natos, qui in cerebrum ascendit, op. cit., p. 378.*

(3) Book II, General Scholium.

(4) Questions, n°s 23 and 24.

of the XVIIIth century, unconcerned with the metaphysical and theological foundations of Newton's physics, and he sees in his work only the canon of positive science. Willis and Newton have, in his eyes, this in common that they found a physiology and a physics on non Cartesian principles. But it is likely exactly that which should alarm Berkeley, in so far as he glimpses a possible extension towards materialism of the non-Cartesian, Newtonian scientists/scholars. It is a contemporary of Berkeley that would precisely take this road. David Hartley (1704-1755) derived, in his *Observations on man, his Frame, his Duty, and his Expectations* (1749) (1), all the possible consequences of the Newtonian explanation of neuro-muscular phenomena. If the action of the exterior objects transmitted by the nerve determines in the brain vibrations of small parts composing the medullary substance, vibrations whose effect is the sensation in the brain and the automatic movement in the muscle, it happens that a repeated action of the same vibrations imprints on the brain a disposition to repeat them in the form of "vibrationcules", whose effect is the image or the idea in the consciousness and the voluntary movement in the body. And thus will is nothing but a composition of "vibrationcules". The combination of the physics of Newton and of the psychology of Locke produces finally all the elements of a materialist explanation of life and of thought. We have showed elsewhere (2) how, having become milieu of distant action, the ether-spirit, imagined by Newton, turns out to be one of the sources for the biological theory of the action of the milieu on the living being in the XIXth century. We see thus how a theological conception of the relations between creature and God, from which Clarke would draw inspiration in his *Deuxième réplique à Leibniz*¹², could be secularized¹³ into an explanation of life by the view of relations of exchange between organism and milieu, a necessary presupposition for the generalization of the concept of reflex as an instrument of mechanical adaptation of the living to external stimulation. If Berkeley is thus careful to not confuse the explanations of Willis and of Newton, it is because the theory of the igneous soul appears to him more capable than the theory of ether to support, at the benefit of / profiting his own philosophical intentions, the anti-mechanism in biology.

One must reckon that in the XVIIIth century the incertitude, to not

(1) HARTLEY's work is posterior by five years to *Siris*. But he had developed analogous ideas in *Conjecturae* of 1741, of which Berkeley might have had knowledge.

(2) *La connaissance de la vie : Le vivant et son milieu*, p. 160-198.

¹²[t.n. Second reply to Leibniz]

¹³trans. note : laïciser, in the original French.

say the confusion, is great, as for the philosophical and practical reach/scope of such or such principle of explanation in biology. For example it is not one of the lesser paradoxes of the history of ideas that the *Encyclopédie* of Diderot and d'Alembert (1751-1758) in which commonly is seen, either cause to rejoice, or for affliction, a powerful organ of diffusion of a materialist philosophy, expose, in the whole of the articles relating to physiology, doctrines of [a] vitalist inspiration. The article *Animal*, written by Diderot, recalls rather the theses of the *Monadologie* than the arguments of the Vth Part of the *Discourse on the method*. The article *Instinct*, of which Diderot is the author, and the article *Ame (des bêtes)*¹⁴, contain critiques of the theory of the animal[s] machines. Article *Sensibilité*, due to Fouquet, doctor of medicine at the Faculty of Montpellier, is important for our subject. He links, among the modern authors, Fernel, Bacon, Van Helmont, Gassendi and Willis to the Stoic tradition of the igneous soul : "The sensitive soul is hence according to these two authors (Gassendi and Willis) a light or a flame, although Willis designates more particularly under that last name the portion of the sensitive soul that resides in the blood ; it is not properly life but it is its attribute, like light or the flare is the attribute of the flame... All of this merits to be read in the authors themselves. See Van Helmont, *passim*, and principally *De Lithyasi* ; and Willis, *De anima brutorum*." Likewise, (the) article *Musculaire* contains an allusion, although quite unfaithful,¹⁵ the explanation of the contraction proposed by Willis : "There are some who, along with the savant Dr Willis, make of the tendons muscles as many reservoirs of animal spirits, by means of which the spirits, according to them, are elevated to the grade of the will ; it is in this fashion / sort ~~que~~ that they are brought in the body of the muscle, where meeting the active particles of the blood, they ferment there, there produce a swelling and contraction thus in the muscle." The energetic phenomenon so carefully described by Willis here is totally ignore. On the other hand, it's to Chirac that is attributed, a few / some lines below, the assimilation of the muscular contraction to an explosion. Whatever apparent contradiction enclosed in the terms by which Mr. Jean Wahl attempts to characterize Diderot : "a vitalist materialist (1)", we must adopt this pertinent expression in order to understand the general inspiration of the biological theories exposed in the *Encyclopédie*. From the moment that one renounces

¹⁴[t.n. Soul (of the beasts/animals)]

the Cartesian distinction of the thought and of the extended¹⁵ and the metaphysical specificity of the reasonable and free human soul, one does not know very well anymore, in the making of a theory of sensitivity and of univocal movement for all the living including humans, if one materializes the soul or if one animates the matter ; in such a way that, to classify XVIIIth century authors — supposing the need to classify minds is irrepressible — one must rather consider their practical conclusions than their theoretical principles. Because there isn't any one up to La Mettrie who doesn't believe, he also, as noted by Mr. Jean Wahl, in a vital force, due to a definition of the matter sufficiently large to admit among the number of its properties the sensitivity at the same title as the extension or the force (1). No need therefore to be astonished when one sees La Mettrie give some attention to the theory of the igneous soul in the form given to it by Willis and to credit him at least with the merit of representing the soul as "generally spread in the entire body", contrary to Stahl's conception (2).

Finally, if we wish to understand the significance of this theory of the igneous soul that Willis takes over from the philosophical tradition for a revolutionary scientific use, which Gassendi and Berkeley utilize for strictly opposite ends, that Haller accommodates in the manner of Newton, and that thinkers, held for [being] materialists, do not disdain/disregard/dismiss in their consideration, psychology takes the risk of showing itself more helpful than history.

And we wouldn't know to do better than to refer to the penetrating pages in which Mr. Gaston Bachelard analyses the intuitions of affective type that may have led to a "calorist" form of animism (3). Among the images of a fundamental interest for the human mind, Mr. Bachelard retains especially that of the flame. "Let us now look at the region where fire is pure. It is, it seems, at the tip of the flame, where color makes place for a vibration almost invisible. Then the fire dematerializes, derealizes ; it becomes spirit (4)." It is in the light

(1) *Ibid.*, p. 75.

(2) L'homme machine, in *Œuvres philosophiques*, Amsterdam, 1774, t. III, p. 74. See also on WILLIS, *Les animaux plus que machines*, *ibid.*, t. II, p. 82. On the sensitive soul of animals and the extent of the soul, see *Traité de l'âme*, *ibid.*, t. I, chap. IX and X. For the first and the last of these references, see also *Textes choisis de La Mettrie*, by Marcelle TISSERAND (Editions sociales, Paris, 1954), p. 182 and p. 73 sq.

(3) *La psychanalyse du feu*, Paris, Gallimard, 1938, p. 151 and 216.

(4) *Ibid.*, p. 205.

should / can this be replaced
by "f."

¹⁵trans. note : la pensée et ... l'étendue. (A main distinction in Cartesian philosophy.)

that the idealisation of fire is done (1). Naturally, Mr. Bachelard does not omit to recall that the equation of life and fire is at the base of the system of Paracelsus (2). But we will keep/retain especially, among the [few] texts of the pre-scientific age cited by him, a word by the marquise of Châtelet which seems to come, straight through the ages, from the physics of Aristotle : "The Fire is the perpetual antagonist of gravity [pensanteur], far from being submitted to it (3)." By bringing closer this affirmation to a passage from *Siris*, we can begin to understand why the fire and its light, imagined as "counter-law" of gravity (4), have been, in such tenacious fashion across the centuries, held to be the matter of the soul and the organ of the animation of the body. "The body is the opposite of the spirit or intelligence. We have a notion of the body through resistance. Wherever there is real power, there is spirit. Wherever there is resistance, there is incapacity or lack of power, which is to say that there is a negation of the spirit. We are corporeal, that is to say that we are pressed by the gravity and stopped by resistance. But with respect to a perfect spirit, there is nothing hard or impenetrable : there is no resistance for the Divinity, hence why it also has no body and the Supreme Being is not united with the world like the soul of an animal with its body : because this union implies necessarily some lack, both due to the body being an instrument as that it is a constant obstacle and weight" (§ 290).¹⁶

The body and the soul have first played in the interpretation of the human experience two opposite roles. The soul was this principle of explanation that lived experiences of dedoubling [dedoublement], recalling, premonition, dream, delirium, required to give an account of that which the distinctive properties of the body, localisation, limitation, gravity, did not permit to deduct. But it was normal that imagination preceded reflection and that the soul was devolved / committed to being a lining of the body, to a singular species of body, that is to say paradoxically to a being of nature analogue to that which the function of the soul was supposed to deny the power of. In the same way that the soul is defined by characteristics opposed to those of the body, likewise it is first imagined as a body constituting an exception to the laws

(1) *Ibid.*, p. 208-209.

(2) *Ibid.*, p. 147.

(3) *Ibid.*, p. 163.

(4) *Ibid.*

¹⁶t.n. very Leibnizian, indeed. Especially argument "the Supreme Being is not united with the world ... because this union implies necessarily some lack" recalls the sine qua non condition of Theodicee. How could there be evil in the world if God is perfect? (But, God is, perfect, therefore... and gears of mad logic start turning.)

of

the bodies. Because the flame elevates/is elevated, Aristotle assigns as its natural site the supralunar world of the incorruptible beings, and because the heat of the cardiac home is the principle of animal mobility, of the fight against mineral inertia, he assigns to the vital fire a supra-lunar origin. It is a parcel of eternal fire that acts, by agitating it, in the perishable body. In the theory of the igneous soul of Willis, like in the theory of cardiac fire, "fire without light", in Descartes, comes dying, after division, an aurora of the modern physiology, a mythology of the flame of which we do not need to seek the origin in history, if it is true that it is found, as is suggested by Mr. Bachelard, in our own ardour.

When Cicero undertakes the expose of the Stoic thesis following which a divine fire unifies and vivifies the totality of beings, it is to examples of organic movements that he asks to suggest the law of freedom, the law of independence with regard to gravity, that rule the fire : "Continuous beating of the veins and of the arteries imitate the agitation of the fire ; and when the heart of an animal has just been ripped out, we see it still palpitating and starting to move¹⁷ like the flame. Hence everything that is living, be plants, or animals, only lives but by the mean of the heat it encloses. The vital principle that acts upon all the universe, is thus heat (1)."

The example of the ripped out heart introduces our study to another kind of problems.

(1) *De natura deorum*, II, 9.

¹⁷trans. note : s'élancer.

CHAPTER V

DECAPITATED ANIMALS AND ORGANIC SYMPATHIES

The study of muscular contraction is for the doctors of the XVIIIth century the principal center of interest in physiology. Myology dominates and commands neurology. If one has an interest in the nerves, it is less in and of themselves than for their relations to the phenomena of movement. When reading Haller, we discover, through his erudition, a legion of theories concerning the animal movement. In 1781, in his work *Über den Bildungstrieb*, Blumenbach counted, based on Drelincourt, 232 theories on the generation proposed so far / up until then. Without being able to, as for the subject of muscular contract^{ion}, to give an account with such similar precision, besides futile, we can say that the number of theories proposed is of a similar order. To only speak of England, we draw attention to that Fulton who kept a list of the most important Croonian Lectures, ~~counted~~ 21 names and titles between 1738 and 1791, and still he forgets, for example, the *Praelectiones de natura musculorum* of Th. Lawrence (1759), despite being cited by Haller and Prochaska as an important work (1).

counted

Yet one of the remarkable traits of the study of movement in the XVIIIth century, is that it does not electively concern Man or the domestic mammals anymore but that it utilizes as experimental objects the vertebrates poikilotherm* (amphibians, reptiles) and even the invertebrates (polypes). It is during this epoch that the frog became, as Fulton has said, with humor, the first of the martyrs of science. And in fact, from

(1) FULTON, *op. cit.*, p. 15-16 and 27-28. See *supra*, p. 70, n. 2. — The first speaker of the Croonian Foundation was Alexander STUART. *Three Lectures on Muscular Motion* (1737). An account is given in this memoir of experiments on the frog.

* trans. note: in this expression, the "therm" part refers to temperature (we believe).

Swammerdam to Goltz, Pflüger and Auerbach, passing by Whytt and Galvani, the frog is, for two centuries, an animal of choice for experimentation in the domain of the functions of the nerves and of the muscle.

We said that Descartes only treated, in anatomy and physiology, of Man and domestic animals (1). But this material of observation and ~~experience~~ ^{experiment} constitutes paradoxically, in the circumstance, an obstacle to the application of the second precept of the Cartesian method, "divide the difficulty", which finds, however, in comparative anatomy, more favorable data and almost naturally prepared, in the sense that they are constituted of structures and of functions not mechanically more simple but physiologically less strictly coordinated. Of this, to our knowledge, no one has had a clearer consciousness than the skilled experimenter that was Legallois. "I see in the scale of animals only that of all possible combinations of organs, capable of maintaining the nervous power with variable qualities like these combinations, but in the end of same nature in all. Among these combinations, the ones that are the simplest and in which the necessary condition for the maintenance of nervous power exists in all the parts, are susceptible to be divided by portions, and life can continue in each portion like in the animal as a whole, or rather each portion becomes a new animal. The ones, on the contrary, in which these conditions are concentrated in certain parts, do not admit similar divisions with the same success ; life cannot continue in the segments that find themselves separated from these parts, only for the time that nervous power can subsist through itself without being renewed (2)." This text offers us beyond this the supplementary advantage of showing how, contrary to a common opinion and which has for itself the authority of Radl (3), physiology did not wait for the diffusion and the credit of Darwinism to become systematically a comparative physiology. Indeed, we see here Legallois referring to the doctrine of Cuvier, when he illuminated the signification and scope of experimental practices to which, as we said following Fearing, the conceptions

(1) Cf. SHERRINGTON, *The endeavour of Jean Fernel*, p. 84.

(2) *Expériences sur le principe de la vie* (1813), Avant-Propos, p. 219. We refer, as for this work, to the 1855 Delahays edition, in which it figures after the *Recherches physiologiques sur la vie et la mort* of X. BICHAT.

(3) *The History of Biological Theories*, translated by HATFIELD, London, 1930, p. 377.

of Willis had given, with a better knowledge of their field of application, a new development/growth.

For we can only speak of a new development/growth. It is certain indeed, that before taking [on] the form of conjugated method and technique, little by little codified, thanks to the results acquired by the critical analysis of the reasons for their previous failures, the practice of excision of organs or the decapitations of animals prolongs gestures and behaviors of Man towards the animal that no intention of scientific curiosity animated originally. To only take one example, having just read in one author that Whytt was the first to describe the movements of a decapitated frog (1764), we find in some other that Bohn described the effects of a similar mutilation in 1686 (1), and then we find [out] that Leonardo da Vinci had related an experiment of that order (2). To go further back in this matter, only erudition ~~lacks~~ which besides, as rich as one may wish it to be, would not suffice to explain ~~the~~ conversion or sublimation of aggression or will to power of defense behaviors or magical rites have ~~led~~ to the experimental gesture of decollation. ^{through what resulted} of extirpation or of excision in the peace and cleanliness/order of the laboratory. The vivisection goes back to the dawn of time, meaning the dawn of instincts and dreams. It exploits in its first and most crude/rough attempts, the effects of gestures whose premeditation was different or even devoid of premeditation. Sectioning the head of a viper, as did Redi or Fontana (3), is to imitate a reaction of conservation. The spade of the gardener, the scythe of the harvester, the arm of the hunter were ahead of / preceded the scalpel of the physiologist (4). The knife of the priest, the Etruscan haruspex, did the same. Drawing from a long heritage made of mythology and empiricism these elementary acts

(1) Johann BOHN (1640-1748), *Circulus anatomico-physiologicus*, Lipsiae, 1686.

(2) "The frog continues to live some hours still after its head has been removed from it, its heart and all of its guts. And were to prick its ~~lowe marrow~~ ^{spinal} spinal cord, it convulses instantly and dies. All the nerves of the animals derive from there : if it's pricked, they die instantly/" *Les carnets de Léonard de Vinci*, Paris, Gallimard, 1942, I, p. 184.

(3) F. REDI (1626-1697), *Osservazioni intorno alle vipere*, Florence, 1664. — F. FONTANA (1720-1805), *Ricerche fisiche sopra il veleno della vipera*, Lucca, 1767.

(4) Read in *Les origines de la biologie expérimentale et l'Abbé Spallanzani*, by Jean ROSTAND (1951), a suggestive text of Edmond Bordage relating to the possible utilization by Voltaire, for the reproduction of the experiments of Spallanzani on the regeneration of the snail's head, of the spontaneous observations of his gardener (p. 90-91).

and its primitive tools, it is likely that the vivisection also draws from it the motives, at first obscure of the choice of the first animals it utilizes. Of course, in the modern epoch, and in proportion with the progress of natural history, the inventive sense of the experimenter pushes him to presume that such organic structure will reveal to be electively favorable to his intervention, to the mounting of his heuristic or demonstrative preparation. Chance also, sometimes, make things right, but only for those who know, that is are worthy enough to not owe it anything. In any case it is well known by biologists that the choice of the studied animal commands often the discovery. As for what pertains to our subject, it is clear that the poikilotherm happens to be an animal less well "regulated" than the homeotherm, and following both less sensitive of its internal states and more sensitive, more docile to excitations/stimulations of the exterior milieu/environment. We have there a favorable condition for the study of the movements of type reflex. But in the end, it was only known after the facts (1). From then on, why so many frogs, vipers, salamanders, lizards in the books of physiology from the XVIIIth century? We will say that it is looking very far, for what is so very near. Any peasant has been able to observe the resistance of an amphibian or a reptile to mutilation and the unusual survival, which is to say the agitation, of their separated trunks/sections. Yet who says vivisection says requirement to maintain life as long as possible (2). But one would be mistaken here, as on so many other points where it is involved, in believing in the naive simplicity of the observations and reactions of peasants. One must have not lived, as a child, in the country-side [campagne], to ignore the strange and complex feeling felt by being able to watch leisurely, finally cut in its escape and brought to day [light], the living that hides ordinarily in the earth, in the grass or in the water, the living which is out of grasp, either because we can't, or because we don't want to catch it intact because it is dangerous or repugnant. The more the animal

(1) Cf. Claude BERNARD : "A brute being has no spontaneity whatsoever that could make it change state. For the living being on the contrary, beyond the exterior environment/milieu that acts upon him, there is an independent interior milieu. The higher the animals are, the more independent they are. Therefore the delicacy and the difficulties of the experiment increases. Experiments are easier in the plants, in the cold blood animals than in the animals with warm blood", *Le cahier rouge*, Gallimard, 1942, p. 46.

(2) SWAMMERDAM justified by this the choice of amphibians as animals of experiment : "*Heic vero nunc animadvertere juvat, quod memorati Musculorum motus in Animalibus sanguine calidiore praeditis haud adeo insignes sunt, cui potius tanto tempore non durent, ac quidem in illis, quae sanguine vivuni frigidiore, uti sunt Pisces, et plura alia aquatilia, multis, paucis, nulmea experimenta semper institui*", *Biblia naturae* (1738), II, p. 838.

escapes Man, the more mysterious it is, the more it stimulates curiosity, the more easily it triggers a frenzy to see, and see further. And since here a preliminary violence was necessitated to enable the vision, what surprise is there that the vision itself becomes, as says Mr. Bachelard, a violence (1). [in]

Besides it would be inexact to think that mammals or birds have not provided, at the end of the XVIIth and during the XVIIIth centuries, their contingent of animals of experiment. Claude Perrault had remarked that the dog survives after the ablation of the brain but that he dies after the ablation of the bulb¹ (2), and Robert Boyle had noted that the heart of a decapitated chicken continues to beat for an hour about. Many other observations of the same kind are reported by Haller and one is astonished that Charles Richet could have written (3) that the classical books of physiology of the XVIIIth century, like for example the *Elementa physiologiae* of Haller, do not almost take into account the experiments of decerebration, of section of the spinal cord, etc. This judgment is unjust for Haller who cites on multiple occasions Robert Whytt, Fontana and among their precursors Redi, Swammerdam, and finally other authors who have worked hard to describe and interpret the automatic movements of separated organs or decapitated animals (4).

On the other hand what may astonish us, is to observe that Haller (1708-1777) who frequently cites Willis never uses the words of reflex movement (5), such that by reading him alone one should conclude that the corresponding notion had fallen into oblivion / been forgotten. If Haller sometimes uses the words *actus reflexus*, it is to designate on the contrary a reflex, the reflected activity (6), the consciousness, and when it happens to him in the course of summary, once, to meet a new abstract/sketch of the notion by his contemporary Astruc, he only mentions it to discard it.

That the notion of reflex movement remained alive we only wish for proof the following testimony. Tome III of the *Disputationes anatomicae selectae* (as *Lienem, Hepar, Renes. Cutem.*

(1) *La terre et les rêveries du repos*, Paris, 1948, p. 7. See p. 7-9 the analysis of the aggressive curiosity of the child, and also, p. 261-89, the beautiful pages on The Serpent.

(2) *Mémoires pour servir à l'histoire des animaux*, 1671-76.

(3) *Physiologie des muscles et des nerfs* (1882), p. 660.

(4) *Elementa Physiologiae corporis humani*, Lausanne, 1766 : t. IV : *Cerebrum, Nervi, Musculi* ; book X, sec. 7, § 31 : *Nervi irritati convulsionem faciunt etiam a cerebro separati*, and § 38 : *Quomodo absque cerebro vivatur*.

(5) Cf. SHERRINGTON, *The endeavour of Jean Fernel*, p. 83.

(6) *Elementa Physiologiae*, IV, b. X, sect. III, 4.

¹trans. note : bulbe rachidien. i.e., medulla in current terminology.

Musculos), collected and edited by Haller (1), contains four dissertations on the muscular movement, by Gottsched (1694), by Deidier (1699), by Winder (1736), by Hingant (1745). In all of them there is talk of Willis and his conceptions are discussed. We will only say a few words about the first, *Dissertatio de motu musculorum*. In the first chapter, Gottsched distinguishes the vital movement and the animal movement, in the latter, the voluntary, natural and mixed movement. In the voluntary and natural movement he distinguishes the direct movement and the reflex movement and in order to make intelligible this distinction he takes up again, without citing its author, the terms and the example chosen by Willis : *Qui uterque tam naturalis quam voluntarius duplex est, directus, ab interno principio seu deliberatione intestina dependens, et reflexus, ab externa causa, ut cum cutis titillatio ejus fricationem ciet, et praecordiorum aestus pulsum et respirationem intentiores accersit* (2). The definition of Willis seems to be so well known that one doesn't bother / take the precaution anymore to surround it with his authority.

The principle reason for the indifference that Haller demonstrates with regard to the notion of reflex is evidently his own conception of muscular contraction. Under the name of irritability, taken over from Glisson, Haller understands a property inherent to the sole muscular fiber, different from the sensibility in that it has for effect a shortening of the fiber, source of animal movement. This force is not reducible to any other property of the body, it does not depend on gravity, nor on attraction, nor elasticity. This *vis propria* or *insita* of the muscular tissue does not only respond to nervous excitation, but is submitted to the influence of various stimulants : pressure, blood, electrical spark. That is why the animals without head and without nerves, like [the] polyps, are very irritable. That is why separated organs, and especially the heart, the most irritable of all muscles, continue to be agitated by movements. The heart and the intestine are constantly irritated : the one by blood, the other by the alimentary/food mass. These observations provide the key of the automatic movement, that is to say of movement that no sensibility reports to the soul and which no voluntary decision commands. And one understands that this dispersion of the power of muscular contraction turns/drives Haller away from focusing on the elucidation of the notion of reflex movement. It is that this notion, as Willis

(1) Göttingen, 1748.

(2) *Op. cit.*, p. 365.

had proposed it, as Astruc was to take up again, was inserted for the time being in a context anatomo-physiological such that the reflection of the sensitive/sensory impression towards the periphery was supposed to be operated only at the level of the encephalon and rendered by consequence any local movement dependent on the anatomical integrity of the central nervous system. This mechanism could, at a push, explain certain phenomena said of sympathy²³ in an intact organism, but rendered very difficult the explanation of phenomena such as the movements of a separated organ or of a spinal animal. In ^{such} ~~these~~ cases the supposed source of local movement was not ^{to be} found anymore in the center but in the periphery, either in the nerve, or the muscle. In one way or another, and in the ignorance in which one still was of the central function of the marrow, held only by a nerve more considerable than the others, an agreement needed to be reached on a sort of dissolution, outside of the encephalon, of the excito-motor power (1). To this effect, Haller asks himself how the life of an animal remains possible after the ablation of the brain (2) and it is here that he reports numbers of / numerous observations relating to insects, to the "quadrupeds with cold blood", frogs (Whytt), turtle (Redi), lizards (Tachard), which remain for a few days capable to walk and even to mate. But to these observations, Haller adds others, which to him seem, justly by the way, of great importance in the matter. Meant are observations on [the] acephalous ^{beaten} ~~been~~ fetus that have lived in the maternal uterus, whose heart has ^{been} ~~been~~ and the members have moved during intra-utero life and even some time after birth. Haller here cites Winslow and Daubenton. We understand the importance of these observations when we find them again later in Prochaska and in Legallois (3). They concern in effect a natural case, and no longer artificial, but further ideal. If the decapitation of an animal interrupts the relations of nerve and brain, these relations nonetheless have existed for a time and one can always pretend at a push that traces or effects remain. The anencephalic fetus presents,

fetuses? pl.

(1) *Nervus resectus et infra divisionis locum irritatus, perinde convulsiones ciet in iis quos adit musculis... Adparet causam motus equidem per nervos demitti, coeterum quaecumque ea causa sit, aliquamdiu tamen in nervo integram et efficacem supresse, etsi nervus a cerebro separatus eam causam nuper non accepit.* Elementa physiologiae, IV, 1766, b. X, sect. 3, § 4.

(2) *Ibid.*, § 38.

(3) See further below p. 125. But Legallois makes the just remark that one cannot understand, by adopting the views of Haller, how the heart is at once physiologically subtracted from the nervous power and anatomically innervated as it is. One cannot understand any more / further that strong emotions can influence the movements of the heart.

²trans. note : A definition was already provided in p. 27 n. 2 (as Canguilhem points out himself, but only further below).

³The Oxford English Dictionary from the early 20th c., being a corrected re-issue of 'A New English Dictionary on Historical Principles', gives the following definition : "b. *Physiol. and Path.* A relation between two bodily organs or parts (or between two persons) such that disorder, or any condition, of the one induces a corresponding condition in the other." Vol. 10, p. 368. Star Trek has multiple instances or illustrations of this doctrine, especially in the - stronger - variant connecting two organisms. First, the empathes, due to their heightened senses, can have this effect, positively or negatively. In an episode of Voyager(?), a colony avoids contact and even more relationships with outsiders due to a strong interlinkage forming after coupling (but apparent technological problems force them to).

as for itself, the remarkable particularity of an organism able of movements, without that the brain could be invoked as possible cause, even for a moment (1).

Thus we think we were able to explain why, if one were to look in the work of Haller alone the state of works in physiology of the XVIIIth century, one could conclude that the notion of reflex invented by Willis there plays no role. And if we needed a confirmation of our interpretation, we would invoke an analogy with more recent events in the history of neuro-muscular physiology. Without looking in the speculative notion of the Hallerian irritability for an anticipation of facts subsequently brought to light, we should remark that when M. Minkowski committed to dismantling the dogma of the explanatory omnivalence of the concept of reflex in matters of animal motility, he sought support on the observations of Wintrebert concerning the idio-muscular movements, on the works of Graham Brown making evident a primitive motor function of the muscle, triggered by hematic excitants/stimulants, and on the existence of an aneural motility in the human foetus (2).

We won't go as far, goes without saying, to reproach to Haller to not have given more attention to a notion that he had not invented and that, as we have just said, found, due to the theory of which it was a piece, as many obstacles in those same facts to which it should provide, in the following century, their principle of explanation. But we will see that Haller has not attributed more (signification) or importance to it when he was conducted by his study subject to meet it again in a contemporary who was renewing its usage by applying it to the intelligence of the phenomena of sympathy.

Signif. case?

When a doctor today strikes/hits the liver of a sick person who suffers from migraines or directs to the dentists a client mobilized by a pain located in the ear, he/they adhere, without always knowing it, to this sentiment of the organic unity that inspired the

(1) One should even add that in the anencephalic the reflex movements present more abruptness than in the normal new-born, affecting even sometimes the form of the epileptoid tremors. Cf. ANDRÉ-THOMAS, Le nouveau-né normal et l'anencéphale, *La Presse médicale*, June 9th 1954, p. 885-6. This phenomenon had struck the doctors of the XVIIIth century. Cf. LECAT, *Dissertation sur la sensibilité des méninges*, Berlin, 1765, p. 234 : "not only these children without brain have had sensations, movements, but, what heightens the prodigy, they have been more vivid, that is to say more sensitive than the others. Why this heightened sensitivity in monsters that should, it seems have been totally deprived of it?".

(2) *L'état actuel de l'étude des réflexes*, p. 6-8.

doctrine of [the] sympathies. The notion of sympathy belongs to the tradition of [the] Hippocratic or synthetic medicine (1).

(1) See, above, the definition by Littré, p. 27.

[...]

(The notion of sympathy is part of the tradition of Hippocratic or synthetic medicine.) It sums up the formula : *Confluxio una, conspiratio una, consentientia omnia*. The notion, today usual of retentissement [echo?] is but a flat equivalent. The permanent facts that support this notion are at times the irradiation of a local pain, at others the simultaneous apparition of dispersed symptoms, at others the plurivalence¹ of a pharmacodynamic action on different organs. Today that we know a little the functions of the autonomous nervous system (said sympathetic, precisely) and the sympathetic reflexes, and also the mechanism of the endocrine reflexes, this notion has lost, if not of its complexity, at least of its mystery. If the doctrine of the sympathies here cuts across the history of the theory of reflex, it is because the elucidation of the causes of these phenomena has provided to the doctors and the physiologists of the XVIIIth century and of the XVIIIth century the repeated occasion to form the hypothesis of para-central nervous communications and of a reflection, along these ways, of the sensory impressions. Nothing astonishing about this, if one admits, with R. Leriche, that nervous pathology is "a pathology of repercussion" (2).

The cause of the sympathies were ordinarily sought, separately or simultaneously, either in the ~~like~~ similar structures of the parts, or the continuity of the membranes, or in the anastomoses of blood vessels, or in the communications of [the] nervous fibers, or finally in the confluence of the sensory impressions in *sensorium commune*.

We limit ourselves, in the examination of these different sorts of causality, to cases of muscular phenomena of contraction, of contracture or of convulsions. Haller reports of them a great variety : trismus provoked by a dental cavity, trismus and generalised tetanus from a badly treated wound of the temporal muscle ; retention of urine from an injury of the thyroid ; vomiting of the nephritic colic ; convulsions due to intestinal worms, to the pressure of the testicles, to tickling (3).

(2) *La chirurgie à l'ordre de la vie*, Zeluck ed., Aix-les-Bains, 1944, p. 55. The quote is extracted from the Inaugural lesson held at the Faculty of Medicine of Strasbourg, on March 13th 1925.

(3) *Elementa physiologiae*, IV, book X, sect. VII, § 30. — Article Sympathie of the *Encyclopédie* of DIDEROT and ALEMBERT contains a very detailed classification of sympathies and constitutes a very remarkable presentation of the state of the question at that time / during that epoch. This article was written by the chevalier DE JAUCOURT.

¹trans. note : noun for the quality of being plurivalent.

Two solutions seemed possible, *a priori*, for the problems posed by such phenomena : either the sympathy of the parts of the body was assured by the soul, principle unique and cerebrally located of sentiment (*sensorium commune*) and movement, or it was by a communication of the nervous fibers at the margin, if one can say, of the central anatomic seat of the soul. And each of these two solutions admitted two sub-variants : on one hand, the function of the *sensorium commune* was conceived as exercising according to mechanical laws, or on the contrary as being an exception to these laws ; on the other hand the marginal nervous communications and the reflection of impressions they enabled were supposed to have no relation with a *sensorium* or on the contrary they entertained with it an obliged relation, which led logically to the extension of the *sensorium commune* beyond the central seat of the soul.

Among the doctors of the XVIIth century who admitted the existence of peripheral anastomoses of the nerves, we find Vieussens (1) and Willis. It is to them that Haller makes allusion when he writes : *Hujusmodi symptomata medici per nervorum communicationes solent explicare* (2). Others, to whose number Haller counts himself, hold these communications for nonexistent, or at least for inoperative : *Alii unice ab anima hanc sympathiam derivant* (3). In that same camp, Haller ranks Astruc, as evidenced by the passage that we cite, with the satisfaction, fairly frequent in the history of sciences, of holding the proof that a great man can pass by, without seeing it, the promise of a theory that the observations of his contemporaries call and that he himself is incapable to sketch : *Quare a situ nervorum in senso communi aliqui sympathiam interpretantur, ut spiritus, qui sensatione gravidi in columellam sensorii communis veniunt, per alium nervum aequali sub angulo reflexum subeant, inque eo nervo sympathicos dolores excitent* (4).

Jean Astruc (1684-1766) (5) is of interest to us, first and foremost, through

(1) VIEUSSENS (1641-1715), professor in Montpellier, author of *Neurographia universalis*, Lyon, 1685.

(2) *Elementa physiologiae*, IV, b. X, sect. VII, § 23.

(3) *Ibid.* HALLER cites, on this occasion, the affirmation of Lawrence : *Ab anima, non a communione nervorum, flunt motus sympathici*, in *De natura musculorum praelectiones*. Cf. *supra*, p. 89.

(4) *Ibid.*, with a note referencing Astruc.

(5) Astruc has taught successively in Toulouse, in Montpellier and in Paris. Dissertation in question is dated 1743 by most authors, notably by Haller himself, by CAYRADE (see further below, p. 142) and by Fearing who only cites Astruc based on Cayrade. But this dissertation figures, under the date 1736, in *Disputationum anatomicarum selectarum*, vol. IV (*Sensus*

his dissertation *An sympathia partium a ceria nervorum positura in interno sensorio* ? (1736). But also through his brief study *De phantasia sive imaginatione* (1723). In the latter, indeed, he uses the distinction, due to Willis, of the direct action (*impetus directus*) of the spirits on the brain and the impressions brought to the brain by a reflux (*refluxus*) of spirits moved from the periphery towards the center and by their reflection (*reflexio*) on the fibers of the callous body (1). The interest/significance of this study, never so far cited to our knowledge, is to show that the usage of the notion of reflex, in the dissertation posterior to the sympathies, is not fortuitous. Among the sorts of sympathies that Astruc distinguishes, he intends to specifically treat of those by which, a part of organism being excited, another suffers a contraction or a convulsion : *Stimulata vel dolente parte una, in contractionem agitur vel convulsione percellitur pars altera longe distans, qua sympathia nihil frequentius* (2). And citing as examples : the occlusion of the eyelids, the deglutition of foods, the expulsion of the fetus, cough, vomiting, and cramp. By the way one will have recognized all that came out of the kind of reflexes. Of these phenomena Astruc wishes to give a mechanical explanation (3). He refuses first the explanation by the hypothesis of communication between nervous fibers (4). He admits indeed that all fibers are separated the ones from the others and parallel in all of their length, from the periphery up to the cerebral center which is their common origin ; there and there only, some influx can pass from one fiber to another. It is thus through the anatomical structure of the medullary substance of the brain that Astruc will give an account of the phenomenon of sympathy or of repercussion at a distance of the excitations/stimulations. This phenomenon is a phenomenon of reflection, but of cerebral reflection. The explanation given by Astruc is a combination of the conceptions of Willis and of Descartes. Like Willis, he admits the double function, sensory and motor, and the double movement, influx and reflux, of the animal spirits. Like him, he admits the reflection of the spirits on

externi, interni, respiratio) collected and published by HALLER, Göttingen, 1749. This collection contains another study of ASTRUC, *De phantasia sive imaginatione mica de motu musculari* (1708). Lastly ASTRUC is known for his *Traité des maladies des femmes*, in 6 volumes, 1761-65.

(1) *Disputationum anatomicarum selectarum*, vol. IV, p. 455 and 458.

(2) *Ibid.*, p. 475.

(3) It is with reason that Daremberg ranks Astruc among the rare iatromechanics of the XVIIIth century. Cf. *Histoire des sciences médicales*, II, p. 849, note.

(4) *Op. cit.*, p. 478.

an intra-cerebral obstacle, like Descartes, he admits the tubular structure of the nerves and their origin in the brain in the form of an opening (*ostium nervi*). Therefrom the following theory, which Astruc illustrates with the example of the reflex of sneezing.

The medullary substance of the brain is composed of cells (*cellulis minimis, tenuissimis... componi*) (1), open the one² on the others, and loosely delimited by the columellae and the fibers. In these cells flock like in a central store, and in order to be distributed by the nerves, the animal spirits secreted by the cerebral cortex². This medullary substance is like the internal and common sense (2).

Then the explanation, from there, of the mechanism of the sympathy on [the basis of] the example of sneezing. Animal spirits flowing back from the nasal mucous membrane towards the brain hit a fiber or a columella. The shock produces in the soul a sensation reported to the nostrils. However in addition to this, on the fiber a reflection of the spirits is produced, in accordance with the law of the reflection of light. "It is also necessary that the spirits be reflected by the cerebral fiber as soon as it is shaken/rocked³ and that they be reflected according to a direction whereby the angle of reflection is equal to the angle of the incident. If we suppose that in this direction a nerve's orifice is present, for example in the present case the orifice of the nerve purveyor of the diaphragm, then the spirits will flow in it with the force according to that which they were reflected and they will violently lift/raise the fleshy/meaty fibers of the diaphragm where they will be carried/brought. Thus it is that, the nostrils being irritated, the diaphragm will be contracted sympathetically according to a mechanism that is convenient, rapid, simple and which could be adapted to the explanation of all the other sympathies of same kind (3)." We meet thus, in Astruc, the explicit usage of the notion of reflected movement, borrowed from Willis, but put back in a context of mechanist physiology of Cartesian spirit and inside an anatomical system

(1) It is almost needless to say that the term of cell does not have here its current meaning, but that it designates, in the etymological sense, a cavity, an interfibrillary gap. Cf. our *Connaissance de la vie*, Appendix I : Note on the transition from the fibrillar theory to the cellular theory, p. 213.

(2) *Op. cit.*, p. 479.

(3) *At vero a mota semel fibra cerebri spiritus reflecti necesse est, et reflecti quidem per eam lineam quae faciat reflexionis angulum angulo incidentiae aequalem. Supponatur prostare in directione illius lineae ostium nervi cujusdam, v. g. in praesenti casu nervi illius, qui Diaphragmati prospicit. Influent ergo in illum spiritus, et influent eo quidem momento quo reflexi sunt, ac fibras carneas Diaphragmati quo deferentur convellent. Sic ergo irritatis naribus contrahetur sympathia Diaphragma mecanismo facili, prompto, expedito, qui ad explicandas caeteras omnes sympathias ejusdem generis potest accommodari.* *Op. cit.*, p. 479.

²trans. note : écorce cérébrale (lit. cerebral peel).

³trans. note : ébranlée.

also different from the system of Willis since the seat of the *sensorium commune* is situated in the cerebral marrow wholly and not in the stria bodies anymore. The notion of reflex is applied to the intelligence of a general phenomenon, that of sympathies, through the generalization of its elective application to the case in which muscular contraction plays a role. Thus the notion of reflex movement reveals itself susceptible of a certain independence relative to the observations whose interpretation it permits and to the theories that it permits to compose.

Robert Whytt (1714-1766), professor at Edinburgh, is well known by all the historians of neurobiology who enjoy recognizing in him the precision of his descriptions of reflex movement, his talent as an experimenter and the importance of his contribution to the knowledge of the functions of the ~~the~~ spinal cord. And if he will keep our attention for a little long while, it is not because he cooperated in the formation of the concept of reflex, but precisely because he did not, for reasons that we will try to establish and of which we will work towards drawing the lessons that they entail. We saw Haller borrow from his encyclopedic documentation descriptions of decapitated animals, to sustain conceptions of neuromuscular physiology without relation to the concept of reflex. We saw Astruc use this speculative concept in the mechanist application of his clinical observations. We will now find in Whytt the simultaneous utilisation of the clinic and of experimentation in the service of an anatomo-physiological analysis hostile to any theoretical conjecture, indifferent to all systematisation. *Treatise of Nervous Disorders*

Whytt dedicates the first chapter of his [*Traité des maladies nerveuses*] (1) to the study of the nature, of the structure, of the function and of the sympathy of the nerves. He declares renouncing all the hypothesis on the nature of the fluid through which is usually sought an explanation of the sensory and motor functions of the nervous fiber. He knows that the functions of the nerve subsist after the rupture of the communication between the brain and it. He refuses the hallerian theory of irritability. It is through the nerve that all the sympathies are explained that link all the organs in the animal body. Any sympathy, any *consensus*, supposes, according to Whytt,

(1) *Observations on the Nature, Causes, and Cure of those Disorders which are commonly called Nervous, Hypochondriac, or Hysterical*, 1st ed., Edinburgh, 1764. French translation under the title *Traité des maladies nerveuses hypocondriaques et hystériques* (Paris, Didot, 1777) preceded by an Extract of the work on *Mouvements vitaux et involontaires des animaux*. It is this French translation that we use for our references of the *Traité des maladies nerveuses*.

→ * trans. note: — ifo.

the sentiment/feeling hence the nerve. Here takes place a particularly important example as it is one of the first experimental facts linked with the function of the ~~the~~ spinal cord in the production of reflex movements : "When we hurt the rear feet of a frog, right after having cut its head, no movement is made in the muscles of the leg or at least it is infinitely small. But when we squeeze tightly one of the feet of the same animal or when we hurt it with a pocket knife, ten or fifteen minutes after the head of the frog has been cut, what happens, ordinarily, are the strongest convulsions, not only in the legs but in the thighs, but also in the trunk and the body properly said, and sometimes the frog is so agitated it changes position (1)." Let us note the precision with which Whytt describes the phenomena familiar today to the experimenter in matter of neurological physiology ; the shock stage consecutive to the section of the nevrax and the re-aparition of reflexes in a constant order.

Like Astruc, Whytt refuses the hypothesis, formulated by Vieussens and Willis, linking the sympathies to the communications between nerves. Like Astruc, he admits that the fibers never present any anastomoses, that their trajectories are distinct from one extremity to the other. The sympathies are owed only to the action of the *sensorium commune* : "It is from this part and by its action that are born the affections of the soul (2)" and "any sympathy must be linked back to the brain itself and the ~~the~~ ~~the~~ which gives birth to all the nerves" (3). The experimental proof being, according to Whytt, that "when we prick any some muscles from the leg of a frog, most of the muscles of the leg and of the thigh go into contraction, even after we have cut the head of the animal, so long as the spinal cord ~~the~~ has remained whole ; but when this medullary substance is destroyed or removed/taken away ~~the~~, the fibers of the muscle that we have hurt have, in truth, a weak trembling, but the surrounding/neighborng muscles remain in a perfect rest" (4). We see in sum that for there to be a sympathetic movement — which is to say a reflex movement — there needs to be a transmission of the sensory impression to the *sensorium commune*, located not only anymore in the brain but also in the marrow. And if Whytt never pronounces himself the words of reflex movement, the

*** spinal cord

(1) *Op. cit.*, I, p. 50-51.

(2) *Op. cit.*, p. 77-78.

(3) *Ibid.*

(4) *Op. cit.*, p. 79.

* trans. note : emportée.
 ** trans note. moelle de l'épine (which we understand
 *** idem ↑ to be merely synonymous)

Treatise of Nervous Disorders

movements that he describes are indeed those that we call such. In the same way that the ~~Traité de maladies de l'homme~~ is famous for containing the protocol of the experiences made by Whytt on the decapitated frog, his previous work *An Essay on the Vital and other Involuntary motions of Animal* (1751) (1) is not less, for containing a description and an analysis remarkably precise and methodical of the pupillary reflex of accommodation to light. In that *Essay*, Whytt proposes to study the so called automatic movement, without holding none the more that the automatism implies its dependence on a purely mechanical construction of the animal body (2). It is because the movement of the heart seems to him the most important of these movements that he immediately embarks on its study. But we only retain from it the general principles of his explanation of muscular movement. He distinguishes three kinds of contraction : the natural contraction, that of the sphincters and of the muscles that have no antagonists, it is constant and insensible, it depends on the nervous force since it is abolished by the excision of the muscle (we identify here the tonic contraction, whose notion, owed, as we saw, to Galen, had since gone lost); the voluntary contraction, variable and inconstant ; the involuntary contraction, violent, discontinuous, rhythmic and necessarily dependent on the application of a stimulus to some organ. Among the examples of involuntary contraction, analyzed by Whytt, we choose the movement of the iris (*Essay*, section VII). This text is less well known, in the philosophical and psychological literature, than the texts from the *Traité des passions* or the *Traité de l'homme* concerning the same phenomena, and it is a [great] pity. The iris comprises two sorts of muscular fibers, the ones with a radiating disposition, the others with a circular and concentric disposition. A lively/strong light leads to the tightening of the pupillary diaphragm through the contraction of circular fibers. The eye accommodates this diaphragm to the brightness of the luminous source and the distance of the object looked at. Whytt shows that the contraction of accommodation does not depend on the direct action of light on the iris, as thought Haller (4), but on the disagreeable sensation of dazzling conditioned by the retina. It is the affection of the sensory principle

(1) *An Essay on the Vital and other Involuntary motions of Animal*, Edinburgh, 1751.

(2) *Essay...*, p. 2.

(3) We recognize here the dilating muscle of the pupil and the sphincter of the pupil.

(4) Cf. FEARING, *op. cit.*, p. 82.

at the origin of the optical nerve which mobilizes the animal spirits towards the pupillary sphincter. We should stress here, due to its coming importance, that combination of an anatomo-physiological mechanism and of a sensory principle of control and of regulation guided by the repugnance of the living for pain. "Such is the primitive constitution of the living human body that the sentient principle, as a consequence of a disagreeable sensation, is determined in the instant to produce in the body movements or changes necessary for the distancing of the causes of that sensation (1)." Thus the explanation given for the movement of accommodation fits inside the general explanatory schema of the sympathy (2), any sympathy implying, we saw, the reference of an impression to the sensory principle.

In a broader fashion, Whytt seeks to answer the question : why are the muscles of animals excited/prompted to contraction by the application of a stimulus (3)? Whytt exposes/presents and pushes back most of the mechanist hypotheses proposed previously/in the past. None to him seems able to account for the fact that the contraction under the effect of a stimulus is not continuous but discontinuous and rhythmic. "These alternative contractions will be easily explained if we suppose that they come from a sensory principle which, in order to get rid of a disagreeable sensation, determines the action of the nerves and gives it an energy which it does not have in its ordinary action (4)." If some contractions suffice to obtain the removal of the irritating object and the end of the painful impression, the muscle goes back to its initial state of relaxation, otherwise the contractions resume and amplify. "If the causes of this movement were not those which we have assigned to it, why then would the muscle have an alternative movement? Should it not remain in a state of contraction until the irritating cause ceases completely to act? (5)."

It is thus not surprising that Section XI of the *Essay*, Whytt interrogates the power of the soul in the production of the vital and involuntary movements. We observe that the theory of involuntary movement remained/stayed, in an author of the XVIIIth century, as/what it had been in Aristotle or Galen, more or less. Nevertheless it is through a rupture with the Aristotelian or Stoic principles of the animal mechanics that

(1) *Essay...*, p. 118-119.

(2) *Ibid.*, p. 183.

(3) *Ibid.*, section X.

(4) *Ibid.*, p. 243.

(5) *Ibid.*, p. 259

(1)

begins this examination. "The human body is made in such manner that that there is no motor that could be called the first ; every movement of an organ depends on another and the whole forms a system far superior to the power of mechanics (*is a system far above the power of mechanics* [t.n. in English i.t.o.]). The heart is indeed the cause for the circulation of blood and the secretion of spirits, but without the impulsion/impulse of the spirits the heart would not be beating. These two motor causes form a true circle and each is reciprocally cause of the other. *These two causes, therefore, truly act in a circle, and may be considered mutually as cause and effect* (2) [t.n. idem]. These penetrating views on circular causality are, to speak truthfully, a bit depreciated by the consequences that Whytt draws from them, having posed as premise that the movement of the heart is perpetual and that the perpetual movement is contrary to the laws of mechanics, he concludes that the beating of the heart and the movement of the blood cannot be attributed to mechanical causes (3). It appears hence necessary that the soul participates to the production of the vital and involuntary movement. The involuntary movements should not be attributed to a principle different from the reasonable soul since some of these movements can be on occasion regulated by will and controlled by it (4). But Whytt defends here against being a disciple of Stahl and thinking that it is as [being] reasonable that the soul presides over the movements of the body (5). How would we explain the movements of children or of [the] idiots? How would we explain that the reasonable soul can be unconscious of the power it exerts. If the soul intervenes in the involuntary movement, it is only as a sentient principle determined by a stimulus and a disagreeable sensation (6), since the general end of any movement of this order is to move away from the organism what bothers or troubles the animal economy. This sentient principle can be unconscious, the law of habits playing here its role.

These hypotheses supposed correct, Whytt must confront them to the problem of separated organs (section XIII of the *Essay*), problem which Haller flattered himself of solving through the theory of irritability. All the muscles, says Whytt, and not only the heart, be these muscles submitted to will or not (that is

(1) *Ibid.*, p. 270.

(2) *Ibid.*

(3) *Ibid.*

(4) *Ibid.*, p. 282.

(5) *Ibid.*, p. 285.

(6) *Ibid.*, p. 289.

be (altern.)

to say should they be streaked or smooth), are agitated by a convulsive movement, although separated from the body (1). Follows a long series of examples of movements of the separated heart, in the eel, the frog, the viper, the rooster, the cat, and tending to show that in any case these movements suppose a stimulus and are not the effect of the structure of the muscle nor of any some mechanism, but of the persistence in them of sensitivity. Therefore the logical necessity to admit, since all reception of an impression supposes a center, that the soul extends its empire to the last fold/recess of the organism. Even if the perception does not take place as such, the impression is not less done by the sentient principle and the movement results from it no less. The experiments done on amphibians show thus, in the eyes of Whytt, that there is a sort of extension of the soul even though the soul is not extended* (2).

We then see Whytt lose himself in conjectures on the fashion with which to conciliate the extension and the unity of the soul, and his genius of observer and experimenter accommodates badly to the poverty of his theoretical concepts. The fact force him to decentralise the non strictly mechanical function of movement and he cannot conceive, outside of the reference to the soul, ~~no~~ explanation of the sentiment. Depending on whether one is more sensitive to the value of these observations or the fragility of what Fearing calls a "semianimism" (3) one will hold Whytt for a precursor or a retardant. We think that he is neither one nor the other. His observations will be taken up but not overtaken/overcome⁴. His sense of the organic totality and the insufficiency of mechanism in giving an account for it, the link that he creates between reflex movements and the fundamental instincts of conservation testify to a great mind. He understood, based on research well conducted, that there was a need to decentralise the seat of command and of control of movements but he did it by dilating so to speak to the dimensions of an entire body the presence of the sole central principle whose idea he got from the animist tradition, without that the thought had ever occurred to him that there existed maybe a multiplicity of centers. He could not admit the explanation of sympathies by extra-cerebral nervous connections because he found no place, on this trajectory, where the sentiment/feeling could have been born, that he thought he needed to refer to the *sensorium commune*. The sentiment/feeling can only be, according to Whytt, a property of the matter whatever modifications

pref.

any

(1) *Ibid.*, p. 348.

(2) *Ibid.*, p. 380-85.

(3) *Op. cit.*, p. 78.

* trans. note : ... n'est pas étendue.

⁴trans. note : dépassé.

one may wish to lend to it and by consequence the sympathy — which is to say in kind the reflex movement — depend^s on a non mechanical principle. And ~~since~~ it situated the *sensorium commune* in the brain, he could not any more, since it is purely mechanical, admit the explanation of the reflection of impressions which Astruc had invented. For Whytt does not ignore Astruc, he refuses to follow him, as evidenced by the text in which he declares improbable the supposition according to which sympathy “is only the effect of a particular situation, of an arrangement or of the connection of medullary fibers in the brain” (1).

although
that alter

Summarizing a brief expose of the ideas of Whytt, to which he recognizes an importance of the first order in the XVIIIth century, Fulton concludes thus a parallel between Haller and Whytt : “If instead of the sentient principle we substitute spinal center or reflex in the work of Whytt, this work loses its XVIIIth century flavor and becomes entirely modern (2).” But we cannot subscribe to this manner of writing history, even of physiology, which consists in speaking of the future in the past by eliding the present. If we can forgive a researcher his ignorances we cannot do the same of his resistances or his repulsions. Whytt could have combined the two hypotheses of extra-cerebral nervous connections and of reflex movement. But this last notion was linked, as well in Willis as in Astruc, in a iatrochemist animist as well as in a decided iatromechanist, to the cerebral location of the *sensorium commune*. It is thus not the anti-mechanism of Whytt that condemned him to not add his contribution to the elaboration of the concept of reflex, since we will see that before the end of the century, when Unzer will have taken up for his own account / re-appropriated the notion of reflection in a physiology of vitalist inspiration, Prochaska will integrate it in a decisive fashion inside a non mechanist conception of life.

(1) *Traité des maladies nerveuses*, I, p. 87 note.

(2) *Op. cit.*, p. 34.

CHAPTER VI

UNZER AND PROCHASKA

Fearing in chapter IV of his study *Reflex action*, entitled : "The extension of the mechanist physiology", situates Unzer and Prochaska between La Mettrie and Cabanis. We hope ~~to be able~~, at the end of our present chapter, to be able to share our surprise at this classification. It is certain that the imposition of a systematic qualification always does some violence of the complexity of an author somewhat original. But, in the present case, the violence and infidelity seem to us to be confined to a misreading/misinterpretation [contre-sens].

J. A. Unzer (1727-1799), professor in Halle, is an author little known by the biologists. This is due without doubt first to his systematical spirit, to his deductive method, to his taste for philosophy which lead him to refer, for the psychological part of his considerations, to Baumgarten and to his *Metaphysics* (1739). What is certain is that, until their translation in English by Laycock (1851), the *Principles of a Physiology of the Nature of the Animal organisms* (1771) (1) stayed a fairly esoteric work and cited only by few specialists of the German language. Prochaska speaks of Unzer with praises, probably due to an affinity of systematical spirit, but Legallois, despite knowing at the beginning of the XIXth century all of the physiological production of the XVIIIth, never cites him while he cites Prochaska many times.

Unzer sees only in the animal body a machine but does not pose the equality of machine and mechanism, because he distinguishes the

(1) *Erste Gründe einer Physiologie der eigentlichen thierischen Natur thierischer Körper*, Leipzig, Widmanns Erben und Reich, 1771. — The English translation from 1851 was published under the care of the Sydenham Society, of London, under the title of *Principles of a Physiology of the Nature of the Animal organisms*. — In his *Lehrsätze aus der Physiologie* (Vienna, 1797) PROCHASKA refers (§ 179) to another work of UNZER, *Grundriss eines Lehrgebäudes von der Sinnlichkeit der thierischen Körper*, 1768.

machines in artificial and natural or organic. The latter distinguish themselves from the former in that they are machines up to their smallest parts, whereas the last parts of the mechanical machines are finally simple physical bodies (§ 5). Bringing together this argument and the ideas of Leibniz imposes itself (1), all the more when, further in this work, Unzer distinguishes again the organism and the machine, he refers not only to the clock, example dear to Descartes, but to the windmill, the beloved example of Leibniz (§§ 660, 662, 663). The animal machines are those that possess specific, original (*ursprüngliche*) powers, animal powers (*thierische Kräfte*) produce immediately animal movements (§ 6). Among the living machines, one must distinguish those that have a soul (*beseeltes Thier*) and a brain from those that have no soul (*unbeseeltes Thier*) and no brain (§ 603) ; consequently, one must distinguish also the forces and the actions of the soul and purely animal forces, nervous forces and actions of the nerves (§ 6). Even though Man, as the most perfect animal, is the principal object of Unzer's study, it is not its unique object. The author intends to throw the first foundations of a zoology, of a natural science of all the animal species, but only following their own proper animal forces.

Unzer defends from being a mechanist and criticizes Descartes (§ 366) just as he defends against being an animist and criticizes the disciples of Stahl and Whytt (§§ 595, 596, 597). "It is an error, he says, to conclude, from the fact that an animal executes animal actions without participation of his nervous force but through animal phisic forces, that all their animal movements are actions of the animal ~~phisic~~ force" (§ 597), which is the error of the Stahlians who hold that all animal movement are the actions of the soul and precisely action of a will of which the soul is unconscious. On this false supposition rests the ancient error and recently renewed by Whytt (*der alte und neuerlich von Whytt erneuerte Irrthum*)), following which the soul of animals are spread in all of the body by means of the nerves, due to the fact that one can provoke in the bodies of decapitated animals, animal movements which must be held for movements of the soul and based on the hypothesis that nothing else, except an animal psychic force, can produce them. Unzer

psychic

(1) *La Monadologie* (1714, German version 1720) : §§ 63, 64.

The work of Unzer is entirely subdivided in paragraphs, such that it is easier to refer to the paragraphs than the pages, the English translation being more accessible than the original German edition.

* trans note : brief explanation of content.

affirms thus that life and soul must be distinguished. Life is not a mechanical phenomenon, but simple living beings are beings without soul (*blos lebendige oder unbeseelte Thiere*) (§ 603).

In the IInd Part of the work : *Die thierische Natur nach ihren blos thierischen Kräften* (*Nerven Kräfte*), Unzer reports a multitude of observations concerning decapitated animals : birds (§ 357), frogs (§§ 367, 490, 495, 583), worms (§ 357), insects (§§ 357, 437). Their movements are animal and thus irreducible to the sole laws of physics and mechanics, from there the conclusion : "The sensitivity of external origin (*der äussere sinnliche Eindruck*) can thus, in the nerves, even if it does not reach the brain, and by consequence does not lead to sensation (*nicht empfunden wird*), produce in the body the same animal movements as if ^{it} were accompanied by sensation" (§ 358). We see here how Unzer, different from Whytt, forges the notion of excito-motor phenomena due to sensory impressions not felt, that is to say not accused by consciousness (1). And that is the reason why he can, contrary to Whytt, make use of the notion of reflection in his non mechanical physiology and form the idea of reflection of sensory impressions not perceived. Unzer distinguishes indeed — perhaps under the influence of the Leibnizian distinction of perception and aperception — between *sinnlicher Eindruck*, *Nervengefühl*, sensitive/sensory impression, feeling of the nerve, and *Empfindung*, conscious sensation.

Indeed the movement must have a relation with the sensitive/sensory impression for the animal forces to be coordinated and subordinated (§§ 665 and 666), for the animal machines composing the animal to be reciprocally dependent (*stehen miteinander in Zusammenhange*) and form a system (§ 671). These relations are assured at times by the brain, at others by [the] ganglions (*Nervenknoten*⁵), bifurcations (*Scheidpunkte*⁶) and plexus (*Verwickelungen*). The subordination of animal machines the ones to the others requires that the animal forces trans-

what can and
and not what
must (alter_h)

(1) We can translate *sinnlich* with sensible, on the condition to understand by that, that which can and not that which must give place to a sensation. We borrow the term "sensitivity" * to translate *sinnlicher Eindruck*. to MILNE-EDWARDS, in a note that he dicates to Unzer (*Physiologie comparée*, 1878-79, t. XIII, p. 120, n. 2).

* trans. note: sensible ... "sensitivité".

⁵trans. note : German is more transparent or descriptive than equivalent French (medical) terms; word-for-word, nerve knots or nodes. (The same is true for the rest.)

⁶trans. note : separation (*Scheide*) points (*punkte*)... The choice by Cavaillès of *bifurcations* for the French translation may not be right, since the former does not imply a two-way separation that the latter appears to suggest.

forms one into the other, for example external sensitive/sensory impression into internal sensitive/sensory impression, at the level of the brain, or be transmitted from one part of the system to another, for example from a nerve to another or to a ramification (§ 671). This natural subordination is not done in all the points of the animal system, but in the natural point of concert of the animal forces (*natürliche Gemeinschaftspunkte der thierischen Kräfte*) (§ 672) (1). The ganglions, the plexus, the bifurcations are such points, and the brain also ; in such sort that we can hold the ganglions and the plexus for the brains of the beings that are deprived of it, anatomically speaking, the brain properly speaking (§ 673).

One can thus understand that, in the animals deprived of brain, movements be provoked by the simple and only nervous action, whereas in the case of animals with brain, it is impossible to decide if the execution of analogue movements depends exclusively on the nervous force or if, moreover, from some power of the soul (§ 366). In the animals of the second sort an external impression, transmitted to the brain, produces there a material idea and a representation of the soul ; in the brain it is returned or reflected (*umgewendet oder gleichsam reflektiret*) and, as internal impression of representation, it makes its way towards the nerves that move the muscle. In the instant of this reflection (*in dem Augenblick dieser Reflexion*), when the external impression is changed in internal (2), the thought comes to the soul and from this fact follows that the movement that this external impression produces in the animal machine is an action of the soul (§ 366). But in a Polype, for example, the external impression makes its way to the nerve until the next ganglion where it is reflected in the fashion of what happens in a brain (*nach der Art wie in einem Gehirne... reflektiret*). "And thus the Polypes could, alone through the mean of external impressions in their nerves, be disposed to all of their animal movements, without feeling, without thinking and without possessing neither brain, nor soul... and yet these animals did not have like simple machines, which is what Descartes thought, but based on purely animal laws that cannot be explained nor derived from physical or mechanical principles" (§ 366).

It is thus that the notion of reflection and reflected impression

(1) UNZER speaks also of centers of animal forces (*Mittelpunkte der thierischen Kräfte*) (§ 673).

(2) That is to say exactly when the centripetal impression is changed in[to] centrifuge impression, the center being here the brain.

become in Unzer an essential element of his principles of explanation of animal movement. All natural points of concert of animal forces are as many points of reflection (*Reflexionspunkte*) (§§ 421, 429). The phenomenon of which Willis and Astruc had conceived, in different fashion, the possibility at the level of the encephalon, of which Whytt could have, with more courage for conjecture, supposed the possibility at the level of the ~~spinal cord~~ spinal cord, Unzer conceives it possible at the level of the ganglions and the plexus, which is to say the sympathetic centers, where we know effectively today that certain reflexes find some of their anatomical conditions. "An external excitation well determined can produce a sensory/sensitive impression well determined, which borrows/uses the way of the nerve, according to its characteristic manner, through which it will be, according to a natural necessity, reflected in the determined ganglions or bifurcations, and constrained/forced to transmit from a distance to some machine a mediate nervous effect" (§ 438) (1). There is why it is in Unzer that we find the explanation for the phenomenon that Whytt had, for his part, only known to give a description, besides perfect : "Such a nervous action due to an internal sensitive/sensory impression, non accompanied of representation, from a reflected external sensitive/sensory impression, is, for example, what takes place when a decapitated frog jumps when we pinch its fingers" (§ 495) (2).

It is quite hard, it seems to us, to apply on the theories of Unzer a label of classification. We see well how Fearing ranks him among mechanists. In the words of animal machine, constantly employed by Unzer, one could put the accent on machine rather than on animal. For a biologist, warned *a priori* against all intrusion of metaphysics in science, the references of Unzer to Baumgarten can seem to be nothing but regrettable outgrowths. We will thus not be surprised if, on the contrary, we are more attentive ourselves to the fidelity which Unzer shows with regard to the ideas of a Leibnizian-Wolffian philosopher. This constant preoccupation, in Unzer, with stressing the irreducibility of the phenomena of animal motility to laws of physics or of mechanics it is the distant echo of the

(1) *Eine gewisse bestimmte äussere Berührung kann einen gewissen äussern sinnlichen Eindruck machen, der im Nerven auf eine sich unterscheidende Weise aufsteigt, wodurch er natürlich nothwendig in gewissen Knoten oder Scheidepunkten reflectirt werden, und in einer entfernten Maschine eine Mittelbare Nervenwirkung hervorbringen muss.*

(2) *Eine solche Nervenwirkung eines innern sinnlichen Eindrucks ohne Vorstellung von einem reflektirten äussern ist die, wenn ein enthaupteter Frosch entspringt, den man in die Zehe kneipt.*

thesis and themes of [the] Leibnizian dynamism. The conception of the animal machine as singular system of parts themselves total, and of specific forces distinct from the quantity of movement is, originally, a Leibnizian conception whose author, by the way, never disdained to found on the biological knowledge of his time. And it is due to the support that he seeks, on the occasion, in an easily identifiable ontology, that we hesitate, as for ourselves, to stick/put on the ideas of Unzer, equally distant from mechanism and animism, the qualification of vitalism.

We find, indeed, in the review to which our study on the historical formation of a concept leads us, the occasion to develop an idea that we have already indicated elsewhere (1). As strange as this affirmation may first appear, the vitalists of the XVIIIth century are not, as the too summary views of many historians of biology or medicine have tended to accredit, some unrepentant metaphysicists but rather prudent positivists, which goes back to / is the same as saying, for the epoch, Newtonians. The vitalism is first and foremost the simultaneous refusal of all the metaphysical theories concerning the essence of life. And that is why most of the vitalists refer explicitly to Newton as a model of a scientist concerned with observations and experiments and who uses, in their interpretation, only notions capable of permitting the formulation, in the form of principles, of facts if not always perceived, then at least inducted, whose cause is not sought in the form of hypotheses. Vitalism is simply then the recognition of life as original order of phenomena and hence of the specificity of biological knowledge. We are inclined to think today that Newtonian physics was not as exempt from metaphysics as was once said, for self congratulation, in the XVIIIth century. The hypotheses that Newton condemned were mainly, as Mr. Koyré has so well said, that of the other physicists (2). Likewise the vitalists were not simple

(1) Cf. *La connaissance de la vie : Le normal et le pathologique*, p. 195. — We have found a confirmation of this idea in the expose of Pr LAIGNEL-LAVASTINE : Sources, principes, sillage et critique de l'oeuvre de Bichat, in *Bulletin de la Société française de Philosophie*, 46^e année, n° 1, January-February 1952, pp. 9-11.

We must signal on this occasion the appreciation oh so intelligent of René DUMESNIL on the vitalism of Barthez : "He wishes besides to attribute to the vital principle only that which the experiment lets him observe, nothing more... He makes of it a sort of postulate and not an entity... The vital principle is an algebraic x ", *Histoire illustrée de la Médecine*, Plon, Paris, 1935, p. 191.

(2) The significance of the Newtonian synthesis, *Archives internationales d'Histoire des Sciences*, 1950, n° 11, p. 15-16.

empiricists. But they were not, either, consciously and intentionally, metaphysicists. Their vital principle, their *vis vitalis*, *vis insita*, *vis nervosa*, were as many names that they gave to their incapacity/powerlessness to hold pure mechanism or the action of the soul as explaining factors for the phenomena of life. And, we have not, of course, the naivety to think that a word, covering a tautology, be a sufficient principle of explanation, but one must have the probity to admit that these phenomena held, justly, for specific only found, in the frame of mechanism or animism, explanations that were acrobatic or ridicule.

In fact, many biologists are so severe when it comes to vitalism but only because they do not distinguish it sufficiently from animism. It is so that Whytt, ranked among the vitalists by Radl and Garrison, is held by Sherrington for "opposed to the vitalists of his time" simply because he did not admit integrally, as we saw, the animism of Stahl and of his orthodox disciples (1). But Whytt was precisely one of the biologists of his epoch who invoked the authority of Newton to support their refusal to go beyond the facts of observation and experimentation (2).

Though our road of inquiry does not pass by J. F. Blumenbach (1752-1840), however since our purpose here is to prop up a proposition whose significance goes beyond its limits, we wish to indicate that this author, dear to Kant (3), presents the anti-mechanist idea of *Bildungstrieb* (*nisus formativus*) as that of a force distinct from physical forces - resembling properties of the living like the irritability, the contractibility, the sensitivity - whose effects are as positively inscribed in the experience/experiment as the cause is solidly inaccessible to reason. And the contradictory status of this idea is compared, by Blumenbach himself, to the idea of attraction (4).

(1) Note on the history of the word *tonus*, *op. cit.*, p. 265-266. Inversely René DUMESNIL makes the remark, about Stahl, that animism is too often also named, by abuse, vitalism, *op. cit.*, p. 178.

(2) [t.n. English i.t.o.] In compiling it [Essay] he has been careful not to indulge his fancy in wantonly framing hypotheses, but has rather endeavoured to proceed upon the surer foundations of experiment and observations... And the theories of Newton, and some few others of the more happy philosophers, have therefore triumphed over all objections, because they were founded on nothing else but plain facts (An Essay on the Vital and other Involuntary motions of Animal, Warning).

(3) Critique du jugement, Méthodologie du jugement téléologique, §81, fin. ^{Space}

(4) Hoffentlich ist für die mehresten Leser die Erinnerung sehr überflüssig, dass das Wort Bildungstrieb, so gut wie die Worte Attraction, Schwere, etc., zu nichts mehr und nicht weniger dienen soll, als eine Kraft zu bezeichnen, deren

needed
earlier

*trans. note: general note on the difficulty, or ambiguity at least, of translating the French "expérience"; which covers both the English experience and experiment (though mostly the latter is ¹¹⁴ meant here/in this context)

On the other hand our interpretation of the historical significance of vitalism, considered as biological Newtonism, is perfectly suited for Prochaska, who brings/contributes to the XVIIIth century, the most explicit and systematical elaboration of the concept of reflex, the one also most rich in future, with regard to knowledge and means of investigation available at that time/epoch. Taking over from Haller to substitute it definitively to that of animal spirits the expression of nervous force, *vis nervosa*, destined to designate that action of an unknown essence of which the nerve is the carrier (1), Prochaska writes: "As this thing is as obscure and as perfectly unknown as is the force of attraction itself, it seems to me just that we should call it nervous force. As for the research of its nature, I leave it to ^{the} very ingenious and sagacious ^{Men} who concern themselves with physical experiments: as for myself, I will try only to establish some of their general properties before going over the special functions of ^{the} nervous system (2)."

Georg Prochaska (1749-1820), professor of anatomy and ophthalmology at the University of Prague, publishes, in 1784, a work of 160 pages: *De functionibus systematis nervosi Commentatio* in the book entitled *Adnotationum academicarum fasciculus tertius* (3). This book seems to have ^{had} little diffusion, at the time, in Austria, and with greater reason outside. Some twenty years later, professor in Vienna, Prochaska was to gain great fame/reputation, as an anatomist, as a microscopist,

constante Wirkung aus der Erfahrung anerkannt worden, deren Ursache der genannten, noch so allgemein anerkannten Naturkräfte, für uns qualitas occulta ist. Es gilt von allen diesen Kräften was OVID sagt: causa latet, vis est notissima. Das Verdienst bey dem Studium dieser Kräfte ist nur das, ihre Wirkungen näher zu bestimmen und auf allgemeinere Gesetze zurück zu bringen. Über den Bildungstrieb, 1781, p. 31 sq., with, to the word Attraction, refers the following note: So sagt, z. B. Newton am Ende seiner Optik: What I call attraction, may be performed by Impulse, or by some other means unknown to me. I use that word to signify only in general any force by which bodies tend towards one another, whatsoever, be the cause.

(1) Milne Edwards thinks that it is Prochaska who substituted to animal spirits the *vis nervosa* (*Leçons sur la physiologie comparée*, XIII, 1878-79, p. 21). In fact Haller had already used this notion (*Elementa physiologiae*, IV, b. XI, section 2, § 15) and PROCHASKA admits so himself (*De functionibus systematis nervosi Commentatio*, p. 82 sq.).

(2) *Haec cum adeo obscura et tam ignota plane sit, sicut ipea vis attractiva corporum, recte mihi videtur vocanda vis nervosa. Hucus naturam inquirendam relinquo, etc., (Op. cit., p. 46-47).*

(3) The work was published in Prague, at Wolfgang Gerle. It was reproduced in 1800 in t. II of *Operum minorum anatomici, physiologici et pathologici argumenti* (Vienna, at Wappler & Beck). It is generally based on this edition that Prochaska is cited. But we had the pleasure of finding the original edition at the Bibliothèque nationale et universitaire of Strasbourg, and it is based on it that we indicate our citations.

[...] Prochaska would acquire a great reputation, as an anatomist, as a microscopist¹, as a practitioner and, one should add, as an adept of the Naturphilosophie.

The work in question entails five parts. The first is a historical review of the principal theories proposed on the functions of the nervous system since Aristotle until the second half of the XVIIIth century. We draw attention/signal the lengthy passage of § 6 relating to Willis, of whom Prochaska had well seen the originality with respect to the physiology of the cerebellum, to the role attributed to the animal spirits in the excitation of involuntary movement, to their mixed nature, sulfurous and luminous, to their reflection in the encephalon, and we note, among others, that Prochaska holds Willis for the first author who explained the sympathies (*consensus nervorum*) through the anastomoses of the nerves. After recalling various theories, concerning the nature of the animal spirits, Prochaska, having opposed the Newtonian method (*via quae a posteriori ad causam ducit*) to the Cartesian method (*via per hypotheses et conjuncturas*) (1) and exposed the reasons for preferring the hallerian expression of *vis nervosa* to the multisecular expression of animal spirits, gets to the general study of the nervous system.

The enunciation of these generalities contains an important remark for the intelligence of nervous physiology. Prochaska reproaches to his forerunners to have been too preoccupied with the study of the brain and insufficiently with the study of the nerves in the animal series. "Is it in all animals that the structures of the nerves, the numbers of their cords, their anastomoses (*concatenationes*) and their ganglions is present the same as in Man/humans? Or rather, which is probable, is not all of this in them simpler? There are not yet observations in sufficient numbers to answer these questions (2)." We see here Prochaska, like Goethe at the same moment, become actively interested in the researches of comparative anatomy and contribute, like him, to fixate the fundamental themes of study for the biologists of the school of Naturphilosophie. Through the generalisation of his neurological problems, Prochaska ceases to pose the equation between nervous force and influx of cerebral origin. The nervous force to him seems proper to any nervous fiber in its relation with the *sensorium commune*, which is not identified to the brain. Prochaska then makes the sum of positive knowledge related to the conditions of apparition and manifestation of the *vis nervosa*. The nervous force requires

f. x ?

(1) *Op. cit.*, p. 29.

(2) *Op. cit.*, p. 38.

¹trans. note : micrographie.

[in order] to act the application of a stimulus, under the influence of which it can vary in intensity depending on the age, the sex, the temperature of the subject, the climate, the pathological state, and the part of the nervous system that is of interest. It is singularly the *sensorium commune* which is apt to augment the nervous force. About this subject, and for the first time, appears in an expose of Prochaska the notion of reflection of sensory impression (1). He recognizes, ~~the~~ multiple times, his debt to Unzer (2), and attributes to him, notably justly, the merit of having recognized as the first in the *vis nervosa* a corporeal sense without concomitant perception (*recte sensum corporeum sine perceptione concomitante dixit*) (3). The discriminate analysis of the functions and the apparatus of sensitivity and of motricity leads to three propositions which have never been formulated with such clarity : the sensory/sensitive nerve cannot give a sensation, cut from its relations with the brain ; the motor nerve cannot give a movement, cut from its relations with the muscle ; but the sensitive/sensory nerve, cut from the brain, and the motor nerve inserted on the muscle can, through their liaison/link in the *sensorium commune*, transform an impression into movement (4).

on multiple
occasions
(altern ;

It is well possible that Prochaska may not have been, as should often be said in the following century and sometimes to depreciate his contribution, an experimenter as adroit/skilled as Whytt and that he may have focused more on the systematisation than the discovery. But it is precisely through that that he is precious to us, since it is the progressive elaboration of the comprehension of a scientific concept that decidedly interests us.

However we wish to insist on this that the novelty of the study of Prochaska consists in that he admits, different from Haller, that the *vis nervosa* is divisible, that it subsists in segments of the organism cut from the brain (5), briefly that the *sensorium commune* is itself divisible, because it is neither the brain nor the cerebellum that constitute the *sensorium commune*, but the bulb² (*medulla oblongata*) and the spinal cord (*medulla spinalis*) (6). Its proof lies in the persistence of the excitability and

(1) *Aucta vero vis nervosa in sensorio communi efficere imprimis videtur ut impressiones externae, in nervos sensorios factae et ad sensorium commune detatae nimis subito et violenter reflectantur, inque nervos motores transilient, et motum ac convulsiones contra animae voluntatem eiant quemadmodum hoc fit in pavoribus infantum et etiam quorundam adultorum qui ab exiguo quantumvis fragore aut crpitu terre fiunt.* Op. cit., p. 52.

(2) Cf. *ibid.*, p. 29 and p. 77.

(3) *Ibid.*, p. 77.

(4) *Ibid.*, p. 78 and 114.

(5) *Vis nervosa est divisibilis et absque cerebro in nervos subsistit.*

(6) *Ibid.*, p. 116.

²see the previous translation note from p. 93.

of movement below the section in the frog whose dorsal marrow has been sectioned (1). Another proof is given by [the] acephalous human fetuses having lived for some time (2). Let us add, to be complete, that if Prochaska proposes the new idea concerning the central function of the marrow, he appears to retain, as for the structure of that organ, the traditional erroneous idea according to which this would be but a big bundle of nerves (*crassus funis nerveus*).

The reflection of the sensory impression at the level of the marrow does not obey only to the simple laws of physics (*non peragitur juxta solas leges physicas*) of equality of the angles of reflection and incidence and equality of the action and of the reaction, but also — and on this point Prochaska develops an idea that we saw appear in the conception of Whytt — to laws proper/specific to the marrow, detectable only by their effects, unknown in themselves. This fundamental law according to which the marrow reflects the nervous impressions is a law of conservation of the living (*nostri conservatio* : reactions of defense, of distancing, of suppression of the harmful/noxious excitation and inverse reactions in the case of useful excitation (3). One should not fail to notice that the example given to support these propositions is precisely the same that Astruc had sought to illustrate the notion of a reflection of the spirits according to the equality of the angles of incidence and of reflection (*reflexionis angulum angulo incidentiae aequalem*) and according to the equality of the action and of the reaction (*influent eo quidem momento quo reflexi sunt*), the example of sneezing (4), that is to say an authentic elementary reflex with a bulbar center. To which Prochaska adds the example also given by Astruc, and already by Descartes, of the occlusion of the

(1) *Ranae medullam spinalem in dorso abscidi. Supervixit huic vulnere aliquot diebus, interim irritando medullae spinalis partem sam quae erat infra sectionem, convulsiones in artubus inferioribus excitavi in toto tempore quo supervixit, plane innumeras. Ibid., p. 62. Cf. for the same example, p. 116.*

(2) In section II of the *Adnotationum academicarum fasciculus tertius*, Prochaska publishes three observations concerning anencephalic human fetuses. The third is followed by a long note on the causes of movement and of life in such cases. After having recalled some similar observations done by Malpighi, Daubenton, Winslow Morgagni, Haller, etc., P. concludes that these facts prove the existence of a force in[side] the nerves which they do not take from the brain (*et in nervis quorum nexus cum cerebro nunquam fuit, est*), p. 189.

(3) *Ibid.*, p. 117.

(4) *Irritatio in membrana narium interna facta excitat sternutationem, quia impressio illa ab irritatione in nervis olfactoriis facta per eos ad sensorium commune defertur, ibi ceria lege reflectitur in nervos motores musculis respirationi dicatis respicientes, et per hos validam expirationem per nares producit qua ab aëre vi transeunte irritamentum avellitur et ejicitur. Ibid.*, p. 117.

pupils (1), of which we know today that it is a reflex mechanism more complicated, with a cerebral step/stage, cortical [at] first then become sub-cortical. But in affirming that the laws of the reflection of nervous force go beyond the ordinary means of a physical mechanism, Prochaska does not intend to deny that [the] movements of reflection are in themselves strictly determined and he picks up again to this effect the comparison through which Descartes sought to render sensible his theory of the animal-machine : *Omnes functiones systematis nervosi pendent ab ejusdem fabrica et natura, non minus ac accurata horarum indicatio fabricae horologii debetur* (2). In sum Prochaska glimpses the subordination of [the] physiological mechanisms in the properly biological sense of the reaction of an organism considered as a whole. It is possible that, there Prochaska had posed himself a false problem and that he may have masked, as Fearing thinks it, with his reservations on the explanatory sufficiency of mechanism in the matter of reflexes, his ignorance of the integrative function of the nervous system that Sherrington should discover. But it is also possible, we think, that he may have had the intuition, permitted after all to a good observer of animal behaviors, of the necessary link between reflex and instinct (3). And Ch. Kayser³ has well seen, in any case, that Prochaska "appeals to a principle of utility or teleological as do still today the theorists/theoreticians of the "Ganzheit" to explain behaviors" (4).

There is another characteristic of the phenomenon to which Prochaska gives much importance and attention, it is its relation to the consciousness. He is not content with introducing the unconscious appearance of the reflex reaction in his definition, he nuances his affirmation with that reservation that the said reaction can sometimes be conscious but while remaining always independent

(1) *Si amicus digito suo appropinquat ad oculum nostrum, licet persuasi simus nihil mali nobis inferendum esse, tamen iam impressio illa per opticum nervum ad sensorium commune delata, in sensorio illa reflectitur in nervos palpebrarum motui dicatos, ut notentibus claudantur palpebrae, et arceant molestum digiti ad oculum attactum.* Ibid., p. 118.

(2) Ibid., p. 45.

(3) "In the physiological conditions, no reflexes or series of reflexes are produced, that aren't triggered or activated by an instinctive factor that is to say linked to the vital interests of the organism whole." "The reflex movements and the integrative processes (nervous and humorous) are in such a way linked to the various external and internal excitations/stimulations which determine them that the latter, in the usual biological conditions lead to objectively useful reactions, that is to say serving the interests of the individual or of the species." M. MINKOWSKI, *L'état actuel de l'étude des réflexes*, p. 60-62..

(4) Réflexes et comportement, *Bulletin de la Faculté des Lettres de Strasbourg*, ~~février-mars~~ 1947 ; ~~numéro de février~~, p. 92-93.

February issue

February - March

³trans. note : Charles Kayser, to whom the book is co-dedicated alongside Bachelard, a physiologist, professor at the Faculty of medicine, Strasbourg.

of the will : "Given that the principle function of the *sensorium commune* consists in the reflection of sensory impressions in motor impressions, one must note that this reflection is done, either unconsciously, or consciously... That such reflections of sensory impressions into motor ones take place in the common sense itself, altogether unbeknownst to the soul, it is what show to us certain movements subsisting in the apoplectics, from whom all consciousness has been taken away : their pulse is energetic, they breath amply and even they raise their hand and bring it, without being aware of it, close to a region of the body that has been irritated. Thus the *sensorium commune* fulfills its function even without the consciousness of the soul, by producing the convulsive movements of the epileptics and even those retractions of the members, when they are pricked or lightly pinched, that we observe sometimes in Men who are deeply asleep, in addition to the movements of the heart and of the respiration... The movements that take place in the animal body, with the consciousness of the soul, but on/over which the soul has no power of will, owing to the fact that they depend exclusively on the *sensorium commune* as being independent from the soul, are : sneezing based on a stimulus applied to the nostril, coughing based on a stimulus applied to the trachea, vomiting based on a tickling of the pharynx or on the absorption of emetic, the trembling/tremors and the convulsions in the chorea and in the paroxysm of intermittent fever, etc. (1)."

From there, Prochaska exposes/presents a general theory of the involuntary movement and of the automatism whose interest is to send us back, at the moment when we are reaching the term/end of our historical and critical researches, to its starting point, which is to say the texts of Descartes cited at the beginning of our second chapter. Prochaska writes that in that part of the nervous system called *sensorium commune* is found located/situated a device (*artificium*) such that at its level the external sensory impressions are reflected, according to specific laws, in the motor nerves, in order to produce determined movements of the muscles. Through this sole power of the *sensorium commune* multiple truly automatic movements take place in the human ; but while multiple animals devoid of a brain are constituted into true automata by the power of the *sensorium commune*, in other, higher animals and in the human the nervous system has been augmented by a brain, and moreover, in the case of

(1) *Cum itaque praecipua functio sensorii communis consistat in reflexions impressionum sensoriarum in motorias, notandum est quod ista reflexio vel anima inscia, vel vero anima conscia fiat, etc., Op. cit., p. 118-130.*

Man, by an immortal soul that faith teaches us to be the gift of a special grace of God. But "the soul for as long as it is joined to our body doesn't produce absolutely any action that would depend entirely and uniquely on it, but all of its actions are done by a nervous system like by their instrument" (1) We have apparently returned to Descartes : the soul utilizes in the voluntary movement a device which can however function independently of it. But the difference between Prochaska and Descartes are considerable in fact, since, according to the first, the brain is not an essential piece in the activity of the nervous system and can only in certain cases accomplish it. Prochaska conceives [of] the nervous system, in the animal series, like a structure that becomes more complicated as one goes higher and where the brain finally comes to its place. Prochaska studies [from] bottom up a hierarchy of nervous centers, Descartes constructs the nervous system from up on down.

And that is why finally, conforming to the spirit and direction of his examination, Prochaska poses the question of knowing if the nervous ganglions play a role in the sympathies, the transformations of impressions and [the] reflections. Meant are not only the sympathetic ganglions (2), but the ganglions of the posterior roots of the nerves of the bulb, of which Prochaska asks why only the posterior roots traverse it (3). Like Unzer, Prochaska concludes that the reflections take place at the level of [the] ganglions. We know that after the discovery by Bell and Magendie of double function motor and sensory of the anterior and posterior roots of the bulb's nerves, it is Helmholtz who would show in 1842 that the axons of the peripheral nerve are linked with the ganglionic nervous cells, and one will surely recognize to Prochaska, in a time of rough microscopic techniques and non existent microtomic techniques, a certain intellectual insight/penetration (4).

(medullar
nerves?)

the

(1) *Ibid.*, p. 130.

(2) In fact, PROCHASKA admits the existence of sympathetic reflexes. *Der sympathische Nerve scheint auch seine Eindrücke ohne Bewusstsein der Seele in seinen Knoten und Geflechten zu reflectiren*, in *Lehrsätze aus der Physiologie des menschen*, § 217. This treatise published in 1797 (Vienna, C. F. Wappler) exists also in Latin under the title *Institutiones physiologiae humanae* 1805, (Vienna, Wappler & Beck). Functions of the *sensorium commune* and its power of reflection are treated fairly rapidly in this work (§§ 215-221).

(3) *Ibid.*, p. 128. Prochaska poses/asks the same question on the subject of the ganglion of Meckel. Meant is the sphenopalatine ganglion. The publication of MECKEL, *De quinto pare nervorum cerebri* is from 1748.

(4) HELMHOLTZ, *De fabrica systematis nervosi vertebratorum*. Cf. FULTON, *op. cit.*, p. 42. — K. E. ROTHSCUH in his *Geschichte der Physiologie* (1953) writes

* trans. note: nerfs rachidiens.

** idem

Waller should confirm, in 1850, the discovery by Helmholtz, during the course of experiments on the degeneration of sectioned nerves (Wallerian degeneration) and it is Kölliker who shows in 1889 that any nervous fiber depends on a neuron located/situation ^{ed} in the nervous axis or in the ganglions.

One can understand now that we could have expressed surprise at seeing Fearing holding the work of Unzer and that of Prochaska for an extension of the mechanist physiology. If it suffices, to be classified among mechanists, that an author conceives of animal movement as determined in the fashion of a thing instead of imagining it as anarchic like an inspiration, we ask who really is going to be left out of such a column of classification? And inversely, if one ceases to be mechanist as soon as one thinks that the functions of the living organism constitute an emergence relatively to the laws of matter and of movement, as soon as one admits for example that the coordination of the sensitivity and of movement pose other problems to the intelligence than the working of a clock or a thermostat, we ask who, with the exception of Descartes, besides reduced to his writings of physiology and supposed puerile or delirious in his metaphysical writings, should not be held for a non-mechanist? No doubt we do not ignore that when trying today to explain the functions of the nervous system through analogy with electronic machines we ask correlatively to "not keep oneself as for this term of mechanism ~~in these~~ ^{to the meaning} that can be given to it by a clock worker/watchmaker or a [garage] mechanic" (1). We do not ignore that the turtle of Grey Walter or the fox of A. Ducrocq realize mechanical models or "simulators" of adaptive behavior, through retro-action of the effector on the receptor, in the proximity of which the Vaucanson automata are really children's games for big people of old. We know that N. Wiener pretends that modern automata exist according to the Bergsonian mode and enclose, just like the organisms, their own duration in the conditions of exercise; such that, if "the vitalism has won the battle so far as the mechanisms too correspond to the ~~structural temporality~~ ^{temporal structure} of vitalism", this victory is but all things considered a complete defeat since "the new mechanisms are just as completely mechanistic as the ancients", therefore one should conclude that

very justly : *Man kann nur diese theoretische Interpretation Prochskas bewundern da er alles Wesentliche über den Reflexvorgang ohne jede Kenntnis des anatomischen Substrates darlegt* (p. 83).⁴

(1) P. DE LATIL, *La pensée artificielle*, Gallimard, Paris, 1953, p. 213.

⁴[t n. "One can only admire this theoretical interpretation of Prochaska since he demonstrated everything that was essential about the process of reflex without any knowledge of the anatomical substrate."]

"the whole of mechanism-vitalism controversy has been relegated to the limbo of questions badly asked" (1). Before the amateurs of questions well asked ~~questions~~ we should excuse ourselves for it, but we think that the authentically important questions are the badly posed questions. A question never seems well asked except in the moment when it receives its solution, that is to say when it vanishes as a question. Unless we should reduce/If not for reducing every question to a type of school problems where the pupil who seeks the answer ignores the solution, while posing that there must be one, at the expense of believing their master ignorant or insane who put them forward to them, one must say that a well asked question is already not a question any more since it entails all the elements of an answer. Without paradox a question can, as such, only be badly posed/put. Perhaps when it comes to life the questions are always badly posed, even when they appear to receive satisfying mechanist solutions, because they are enunciated in terms whose meaning is already outmoded/overcome⁵ in the moment itself when we use them. We mean to say that each attempt of reduction of the organic functions to a mechanical system forgets simply that it is not the definitive form of knowledge in the matter. [The] vitalism is maybe but the sentiment of an ontological anticipation, therefore chronologically irrecoverable, of life over mechanist theories and techniques, over ^{the}intelligence and simulation⁶ of life (2).^{**} Concerning the mechanist explication of the functions of the nervous system, we will limit ourselves to two remarks. This system remains capable of characteristic performances after removals or degradations that no machine, especially at an electronic scale, could support, without errors, even a minimal part. The nervous system, if it is a mechanical construct, happens to be in Man / the human a constructing construct and not just constructed (3).⁶ In an organism what-

explication?
erecting
itself
out ~~of~~
*

(1) *Cybernetics*. Hermann, Paris, 1948, p. 56 ; cf. also p. 49.

(2) Cf. our *Connaissance de la vie* : Aspects du vitalisme, p. 101-123.

(3) Cf. Raymond RUYER : "There are machines in the organism, comparable to constructed machines, but it is contradictory to think that there are only machines. If I'm cold and I should make violent movements to warm myself, I will stop when the result is reached ; but, evidently, above me there is no engineer, who would be to my organism what I am to a heater, capable to insert in[to] my brain the material indication of the degree of heating desired. Or if this engineer existed, the same question would be asked again for him, and so forth and so on to infinity. The cyberneticians here as in the other cases, go above this logical demand/requirement." *Le problème de l'information et la cybernétique*, in *Journal de psychologie*, October-December 1952, p. 411. Cf. also by the same author, *La Cybernétique et l'origine de l'information*, Paris, Flammarion, 1954, p. 97.

⁵trans. note : dépassé.

⁶trans. note : montage ... monteur ... non pas seulement monté.

*trans. se fausser

**trans. note :

123
formula "the intelligence and simulation of life" appears useful as the dismissal of cybernetics and aforementioned simulations.

ever it may be, an authentic non simulated relation, natural and non artificial, of retro-action demands an individuality irreducible to a compound. Unzer and Prochaska, as well as Whytt, did not say, in their fashion, anything else. As for Descartes, may it displease the mechanists and cyberneticians of the day, his superiority over them resides in his incoherence, in their eyes, which is to say, we have already highlighted it, in the presentation of his biology as a "form" of mechanism on a "foundation" of metaphysics.⁷ If we understand by vitalism, as we suggest, the consciousness of the specificity of organic phenomena or, to speak like Auguste Comte, the refusal to reduce the superior to the inferior, one must recognize that in the matter of the physiology of the reflex movement the vitalists of the XVIIIth century answer well to "the evidently progressive intention" that Comte recognizes ~~to~~ the general spirit of the method from which he draws inspiration (1).

takes
(alterh.)

We can then ask, incidentally, why the history of the concept of reflex never meets any of the French vitalist doctors of the end of the XVIIIth century and singularly Bichat (1771-1802) who was interested in the question of sympathies (2). Of which he admitted four sorts : sympathies of animal sensitivity, for example the phenomena of reported or delayed pain ; sympathies of animal contractility, for example the voluntary convulsion of a muscle whose ligaments are distended ; sympathies of sensory organic contractility, for example the modification of involuntary movements, such as the beatings of the heart; sympathies of organic sensibility and of insensible/insensitive contractility, that is to say tonic in general. This classification rests on the properties of the various tissues of the animal economy. Yet the reason why Bichat does not link the mechanism of sympathies to the nervous system is that he admits two sorts of sensitivity and contractility : organic and animal. The first belong, according to different modalities, to all the tissues, and make it so, per Bichat, that all tissue directly irritated can contract itself under that influence ; the second only suppose the neuro-muscular apparatus/device. Due to the fact thus that the sensitivity, the motricity and their relations are not everywhere the specific effects of a specialized ~~time~~ device, their study does not refer obligatorily to the study of the nervous system

space

device

(1) *Cours de philosophie positive*, 43^e leçon, ed. Schleicher, III, p. 342.

(2) De l'influence nerveuse dans les sympathies, in *Journal de Médecine, Chirurgie, Pharmacie*, 1801, p. 472.

⁷trans. note : une "forme" de mécanisme sur un "fond" de métaphysique.

Hence it is for having admitted in the *Recherches sur la vie et la mort* (1800)⁸ the relative independence of the two lives, organic and animal, that Bichat, besides more of an anatomist than a physiologist, was not interested, neither experimentally, nor theoretically, in elective fashion in the mechanism of the nerve-muscle relation.

It is on the contrary by contesting the distinction of the two lives, owed to Bichat, that Legallois (1770-1814) should confirm, in a purely experimental fashion, the descriptions of Whytt and the conceptions of Prochaska concerning the functions of the spinal cord⁹. Legallois does not make any theory — which does not mean that he ignores or hates those of his forerunners — and we do not find in him the notion of reflex. We wish to cite him nevertheless, due to his rare qualities of experimenter. Legallois has shown all the importance of the choice of experimental animals, by insisting, the first it seems, on ^{can} the express condition to fulfill for any useful comparison of prepared animals and trial animals¹⁰: it is not sufficient that they be of the same kind, they must be rigorously of [the] same age, and one must compare the results of the experiments covering lots of subjects of a different collective age (1).

that must be fulfilled (altern.)

Legallois first operated on rabbits, then on dogs, on cats and on guinea pigs. He has also studied the respiration of the anencephalic fetus, on the occasion of problems of legal medicine posed by the decollation of the fetus during birth/delivery. Legallois knew to distinguish, in the effects of the section of the nevras, the troubles of the coordination of movement and the production itself/even of movement. He had the idea to proceed by progressive sections from the brain [onward], in order to comparatively detect the exact point at which certain functions cease, while others subsist (2). He could thus establish as the first the

(1) "One of the things that have harmed the progress of experimental physiology the most is the little attention and I could even say the absolute negligence that [the] experimenters have put in the choice of animals. They took them just as they received them / got their hands on them, without [any] distinction of species nor age, and they compared the results of various experiments, done/made in this manner, as if all of them had been on animals of the same species or even of same age. I've followed a plan entirely different, etc." *Expériences sur le principe de la vie* (1812): Addition to serve as supplement for what could be missing on the details of the experiments mentioned in this work. — We hold this terminal note for a very remarkable methodical and technical expose, and we ask ourselves why Bell, per FEARING's own say (*op. cit.*, p. 123), regarded the experiments of Legallois as rough/gross. Maybe it is only because Legallois does not cite the works of Bell on the medullary roots of the bulb's nerves*, published in 1811, which he could have ignored in 1811-12?

(2) "Every time while/when destroying a certain portion, either of the brain, or of the spinal cord, we suddenly make a function cease and before the time/epoch known in advance when it would have ceased naturally, we can be

⁸trans. note: it is possible that Canguilhem, in some form or way, drew inspiration from this book for the choice of title of his collection - memories and thoughts - about the "life and death" of Cavailles.

⁹trans. note: The *moelle épinière* is the spinal cord. The bone marrow corresponds to the *moelle osseuse*. Unfortunately, to accelerate the process of translation, we've carried over this uncertainty throughout, for far too long. (The former is far more often meant, if not always.)

¹⁰trans. note: animaux témoins.

* nerfs rachidiens

transfer
to the first
occurrence
p. 14

metameric character of the spinal cord and to verify that each segment functions as a proper center in the region whose sensitivity-motricity it coordinates (1). If one adds that Legallois has had the sentiment that any experimentation, thus practiced, puts the subject of the experiment in a pathological state (2) and that the conclusions that one draws must take this into account, one will understand why we have insisted, with regard to his insight/penetration, on mentioning briefly the merits of the author of *Expériences sur le principe de la vie* (3).

*
* *

No more than we find in Legallois, no more do we find the concept of reflex in the writings of authors who, during the first third of the XIXth century studied experimentally the structural — anatomical and histologic — and functional conditions of movements of which the spinal cord is the center. The putting together¹¹ of novel techniques in microscopy, in microtomy, the practice of coloration of slices will permit rapid progress in knowledge of fine anatomy. We can say that in matters of reflex movements, the theoretical study of the function has preceded the observation of the morphological structure. At the end of the XVIIIth century, the elements of the concept of reflex are known in the classical form that they will retain for a hundred years in the treatises and teaching manuals. The moment has hence now come for us to present, in

assured that this function depends on the location that we have destroyed. It is in this manner that I have recognize that the first mobile of the respiration has its seat in the location of the oblong marrow (the bulb) that gives birth to the nerves of eighth pair, etc." *Expériences sur le principe de la vie*, *op. cit.*, p. 250.

(1) "If instead of destroying the marrow, we do transversal sections there, the corresponding parts at each segment of the marrow enjoy sensitivity and voluntary movement, but without any harmony and in an independent manner between each other as if we had cut transversely the entire body of the animal at the same spots ; in one word, there are in this case as many centers of sensation, very distinct, as we have done segments in the marrow." *Ibid.*, p. 249.

(2) "The action of the brain on each point of the marrow has not only for effect to determine and to regulate the movements but it seems to augment the energy. Movements are always weaker in the decapitated animal than in the one that is not : except ~~as before~~ if one does immediately touch the piece of the marrow, because then movements become very strong and even convulsive. It is true that this weakness of movement can also depend in part that after decapitation, the marrow is still in a pathological state." *Op. cit.*, Avant-Propos, p. 218.

(3) The works of Legallois have been the object of a remarkable comparative and critical analysis in a *Rapport* made to the Classe des Sciences mathématiques et physiques de l'Institut on September 9th 1811. signed by HUMBOLDT, HALLÉ, PERCY, and countersigned by CUVIER, perpetual secretary. *Op. cit.*, p. 271.

¹¹[t.n. mise au point]

abridged and synoptic form, the steps of the formation of the concept and the exact responsibilities of the authors that have contributed to it.

Copernicus?

Since the Renaissance, until the end of the XVIIIth century, and under the influence of ideas provided by the Aristotelian or Galenic tradition, the questions relative to the physiological mechanism of involuntary movement receive various solutions but almost always inscribed in a vision of the human microcosm which is not without analogy with the ante-Copernican vision of the macrocosm. It is an anthropocentric vision of the animal organism in general and of the human body in particular. If Copernicus, Kepler and Galileo have classified the anthropocentrism of the theory of the movement of celestial bodies, this anthropocentrism subsists in the theory of the movement of Man. We mean to say by this that, lodged in the heart according to the Aristotelians or lodged in the brain according to Galenists, a single principle of command and control of all movements is supposed to dominate and subordinate the whole organism. The heart or the brain are to the animal body that agitates around the one or the other held as center, what Man was, in the Ptolemaic astronomy, to the celestial bodies/stars that rise and decline in relation to his terrestrial journey, what was the king, in monarchic politics, to obedient subjects. The Copernic revolution, in the physiology of movement, is the dissociation of the notions of brain and of sensory-motor center, the discovery of excentric centers, the formation of the concept of reflex. This revolution did not happen in one push, without timidity, without concessions to the traditional conception of animal motility.

One must say that the difficulty was no less great in the case of the organism than in the case of the world, because the character of manifest totality presented by an organism both sensitive and mobile imposed the idea of a unity of the indivisible principle of information and reaction, of common sense and the common motor. The mechanist conception of life is not, on this question, as radically innovative as one could first believe it to be. For a machine only being machine in its whole, its automatism requires a cohesion that excludes the division or scattering of the device of regulation of its mobile parts (1). From Descartes to Prochaska and Legallois, the idea had to be formed with difficulty of a neuro-muscular device that would not only be a ~~system~~ but a system of systems and which as a following consequence, while assuring the functioning of the organism

needed /
alter /

(1) Cf. DESCARTES, *Traité des passions*, art. 30.

as a whole, permits a certain independence of partial automatisms and institutes the coordination of sensitivity and of movement not from up on down like in a monarchy of divine right and by delegation of the central power, but bottom up from a federal republic and by integration of local powers. A vitalist conception, or if one prefers organicist, of the animal body would reveal itself, finally, more favorable to the hatching/blooming of such a way of seeing than a mechanist conception (1). An organism can be composed of parts themselves organised whose *consensus* depends, at each degree of complication, on links/liasons/connections capable of subsisting even after their liberation with respect to a center of higher integration or of control.

But the difficulty to conceive first, to seek to prove second, the decentration¹² of the center of the sensory-motricity was doubled by another difficulty equally grave which was not of anatomical order anymore but of psychological order, and more exactly reflexive. A concept that linked directly, without passage through the cerebral relay, the sensory impression to the motor reaction, stimulation to response, enclosed a contradiction since one needed to admit the existence of sensory impressions not felt. Who says sensitivity says consciousness of the sensation and, and at the time/epoch, this meant the soul. If one were to explain the sympathies by a para-cerebral reflection, which is to say extra-spiritual, of impressions coming from organs of the senses or link to pathological states, thus supposed affective, who to retain for these impressions their qualification of sensitive? It is not the nerve that feels, it is the soul. Therefrom the impossibility to conciliate the notion of *sensorium commune* and that of its mechanical substrate, of locating the *sensorium* in some device that had/sustained no relation with the me [t.n. le moi]. One arrived at this same absurdity that Kant objected, in his *Letter to Sömmering* of the 10th of August 1795, to any attempt towards determining the seat of the soul : "The required solution of the seat of the soul which is demanded from metaphysics has an impossible size $\sqrt{-2}$ (2)." But it is not only the metaphysics, it is also the physiology that seemed

(1) This would undoubtedly not apply to a vitalist like Barthez (cf. RENÉ DUMESNIL, *Histoire de la Médecine*, p. 191), but the history of the concept of reflex never meets him directly.

(2) SÖMMERING had dedicated to Kant his memoir *Über das Organ der Seele* (1796) where he defended that the *sensorium commune* is found in the serosity of the ventricles of the brain. — Cf. in Jules SOURY, *Le système nerveux central*, I, p. 482-85, an interesting account of the ideas of Kant on the seat of the soul.

¹²trans. note : décentration.

condemned, in its state, to an impasse. To continue to be able to speak of sensitive impressions propagated along [the] nerves separated from the brain, it would have required in some sort of the soul that it was still in the location, there from where it had been chased, it had been pretended. And that is why, if a theory like that of Whytt was physiologically unacceptable, it was not philosophically absurd. The soul is everywhere where there is a sensibility and only habit explains the cases of unconsciousness of this sensitivity. Whytt could have said, like Kant in *Dream of a Spirit-Seer*¹³ (1766) : "I am where I feel. I am also as immediately at the tip of fingers as in the head (1)", but by adding that I do not not feel myself feeling everywhere where I am. And through this Whytt found himself pushed, as we saw, to put in the second plane of his preoccupations the anatomical location of the reflex function which he had so well described without naming it. Inversely, when Prochaska sought to localize the power of reflection in the spinal cord he could not keep himself from conceiving of the *sensorium commune* as a medullary soul. It is for the same reason that in the XIXth century, when the generalisation of the concept of reflex will have given birth to a theory accredited by its experimental verifications, certain authors, and not among the least, that adopt it will continue to pose the problem of the existence of a consciousness or of a medullary soul (2). It is little by little that all reference[s] to a subjective experience will be eliminated from the definition of the sensibility or more exactly put in[side] parentheses. One will define objectively the function of sensibility by the histologic structure of the receptors of excitations/stimulations, in the sense of the conduction of the influx on the nervous fiber. The sensibility will be [going forward] a centripetal nervous phenomenon. But for not being posed anymore

(1) The study of this text, way too neglected would merit to be done in connection with the theories defended at the time/epoch on the anatomy and physiology of the encephalon and, of course, first with the theory of Swedenborg. Cf. on this last point, Martin RAMSTRÖM. Emmanuel Swedenborg's Investigations in natural science and the basis for his statements concerning the functions of the brain, in *Till Kungl. Vetenskaps = Societeten I Uppsala*, Uppsala, 1910.

(2) It is notably the case of Eduard Pflüger. The physiologist whose discovery of the laws of reflex has made famous thought that consciousness is not uniquely linked to the functions of the brain, that it is coextensive to all the nervous system and that it is still present in the marrow separated from the brain. Pflüger sustained with Lotze a controversy on this question, whose narration can be found in FEARING, *op. cit.*, chap. XI, p. 161 sq.

And in 1872, J. RANKE, in his *Physiologie des Menschen* (2nd ed., Leipzig) still posed the question of the existence of a medullary soul. He answered besides by the negative, but did not believe to be able to elude the question.

¹³trans. note : the French title is given in the original text, *Les rêves d'un visionnaire expliqués par les rêves de la métaphysique* [The dreams of a visionary explained the dream of metaphysics].

in the works of physiology, the psychological problem of the sensibility has not been annulled/abolished.

That being said, we are bound to recall that Descartes proposes a general theory of involuntary movement, founded on the supposition of a mechanical determinism of structure and of function, commanded from above by two independent centers but conjugated, the heart and the brain. In the kind of involuntary movement it is Willis who, the first, has inscribed the specific words and notion of reflected movement, obeying to the physical law of [the] reflection of light, in the context of an energetic theory of movements commanded by the sole encephalic center. The words of reflex movement, more than the notion, make a fugitive apparition in a mechanical biology, that of Baglivi. There goes the XVIIIth century.

In the XVIIIth century, the notion of reflection of nervous influx, according to the physical law of [the] reflection of light, is used systematically by Astruc, in a mechanist theory of the sympathies admitting the unicity/uniqueness of a center of reflection, the brain. The phenomenon of the reflex is described, without utilization of the word nor of the notion, by Whytt ; but the laws to which this phenomenon obeys are supposed to be not purely physical owing to the fact of the link of the reflex reaction with the instinct of conservation. Whytt defends that the relation of the sensitivity and the motricity is not centralised but diffuse, not mechanical but psychic, and does not assign consequently any specific anatomical support. Unzer thinks, he also, that the law of the phenomenon is not strictly mechanical, but he uses systematically the term and notion of reflection in[side] a decentralizing theory of the sensory-motor relation to which he assigns multiple anatomical supports (ganglions and nervous plexus, and also brain). Finally Prochaska retains the word and the notion of reflection, subordinates his physical mechanism to a sense of conservation of the organic totality, decentralises the reflex function by assigning as explicit anatomical support the bulb and spinal cord (and likely also the sympathetic ganglions) and notes, apparently the first, that from the automatism of the reaction does not necessarily follow the unconscious[ness]. Legallois establishes, which Prochaska had not done, that the spinal cord does not have a structure of nerve and reduces, without using the word nor the notion, the reflex function to a medullary function of which he shows/demonstrates experimentally the metameric division.

nerve structure
alter...

There is thus in 1800 (1) the summary definition of the concept of reflex, ideal definition in its whole, but historical in each of its elements, with the indication of authors who have explicitly formulated first or taken up for their own account these elementary notions : *The reflex movement* (Willis) *is that which, immediately provoked by an antecedant sensation* (Willis), *is determined according to the laws of physics* (Willis, Astruc, Unzer, Prochaska), [*and in relation with instincts* (Whytt, Prochaska)], *by the reflection* (Willis, Astruc, Unzer, Prochaska) *of sensitive nervous impressions into motor ones* (Whytt, Unzer, Prochaska) *at the level of the spinal cord* (Whytt, Prochaska, Legallois), *with or without concomitant consciousness* (Prochaska).

(1) We cheat slightly by citing LEGALLOIS, whose first *Mémoire* on the experiments of section of the marrow date from 1809. As for Whytt we only cite him in so far as his conceptions coincide with such or such point of conceptions elaborated by authors using expressly the notion of reflection.

the

CHAPTER VII

HISTORIOGRAPHY OF THE REFLEX IN THE XIXth AND XXth CENTURIES

[HISTORY OF HISTORICAL OVERVIEWS...]

In 1811, Sir Charles Bell (1774-1842) established that the excitation/stimulation of the anterior root of a spinal nerve⁸ determines a muscular contraction in the dorsal region and that the loss of sensitivity is induced by the section of the anterior root (1). In 1822, François Magendie (1783-1855) confirmed what was then called the Bell law through experiments of section of the anterior and posterior roots (2). In 1832-33, Marshall Hall (1790-1857) describes the characteristics, experimentally determined, of what he calls "reflex action" (3). It is also in 1833 that Johannes Müller (1801-1858) publishes his works on the reflex movement (4). In 1836, R. Remak (1815-1865) publishes his microscopic observations on the structure of the cerebro-spinal nerve (5). In 1844, Rudolph Wagner (1805-1864) proposes, the first, the schema of a reflex arc. This schema represents the functioning mode of the electric organ of the torpedo. It entails two cells : a sensitive/sensory cell of the ganglion of Gasser whose peripheral prolonging constitutes a fiber of the trigeminal and whose central prolonging is in direct relation with a neuromotor cell of the ganglion of the electric organ (cell

(1) *Idea of a new anatomy of the brain*, London, 1811.

(2) Expériences sur les fonctions des racines des nerfs rachidiens, in *Journal de physiologie expérimentale*, Paris, 1822, p. 276-269 and 366-71.

(3) On a particular function of the Nervous System, in *Proceedings of Zoological Society*, London, 1832. — On the reflex function of the medulla oblongata and medulla spinalis, in *Phil. Transactions Royal Society*, London, 1833.

(4) *Handbuch der Physiologie des Menschen*, I, Koblenz, 1833 : *Die Mechanik des Nervensprinzips*.

(5) Vorläufige Mittheilungen microscopischer Beobachtungen über den innern Bau der Cerebrospinalnerven und über die Entwicklung ihrer Formelemente, in *Archiv für Anat. Physiol. u. wissenschaft. Med.*, Berlin, 1836.

⁸trans. note : nerf rachidien.

[previously always translated as related to the 132 bulb, i.e. bulb's nerves.]

assimilated by Wagner to a medullary motor cell). It is in that last/latter cell that the reflection of the influx towards the electric plaque of the tegument [integument] (1). Such There are the dates for the principal contributions of anatomy and of physiology to the knowledge of the reflex, in one third of a century (2). takes place

The history^a of the concept of reflex has for origin a polemic of an extraordinary violence relating to the originality of the discovery of Mr. Hall. Who had a very high idea of himself, boasted/prided himself of twenty-four thousand hours of work that his researches on the reflex had cost him, and if he cited the experiments of Redi, of Whytt and of Legallois, he did not attribute to them any importance. Winner without modesty, all the more

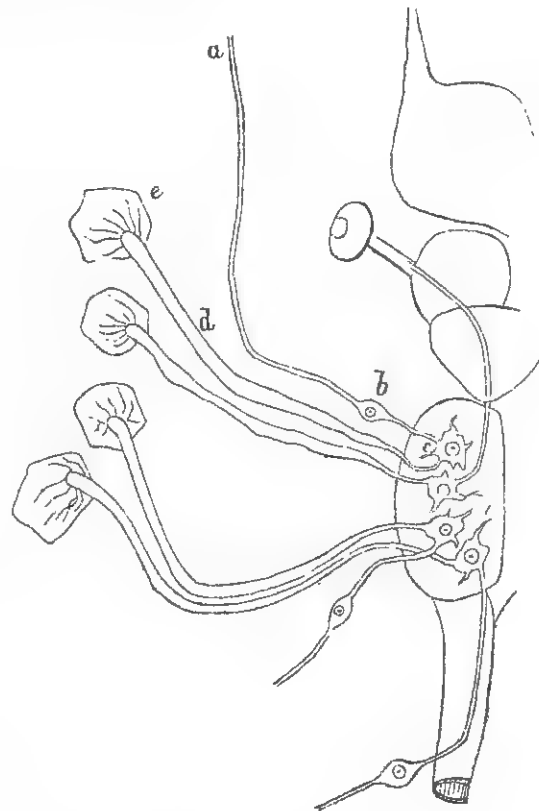


FIG. V. — First schema of a reflex arc proposed by R. WAGNER (1844) (electric organ of the torpedo)

- a : fibril of the trigeminal nerve, second branch ;
- b : Gasser's ganglion^a ;
- c : ganglionic body of the electric organ (homologue of the effector neuron of the anterior horn of the marrow) ;
- d : efferent fibril (electric branch of the trigeminal) ;
- e : hexagonal disc or electric elementary plaque.

(1) *Handwörterbuch der Physiologie*, III, sec. I : *Sympathischer Nerv, Ganglienstruktur und Nervendigungen*, p. 398. Brunswick, 1844. Cf. opposite figure.

(2) A good bibliography concerning the anatomo-physiology of the reflex, from 1833 to 1880 about, can be found in the *Index Catalogue of the Library of the Surgeon General's Office United States Army*, Washington, 1888, vol. IX, p. 806-7 : Nervous System (Reflex action of).

^atrans. note : l'historique. (more on this term below.)

^atrans note : the trigeminal ganglion.

proud as two months later the priority of the discovery could have gone to J. Müller (1), Hall was about to be reminded by others that he had had precursors. That is how the researchers or ~~the~~ claims of intellectual paternity feed in part the history of sciences.

In the Memoir of 1833, on *The reflex function of the medulla oblongata and medulla spinalis*⁹, Hall distinguishes four sorts of movements : voluntary, commanded directly by the brain ; respiratory, depending on the bulb ; involuntary, namely the irritability under the condition of a stimulus applied to the neuro-muscular fiber itself ; and finally a certain kind of movement that subsists after the ablation of the brain or the cerebellum, movement which is under the dependence of the marrow and is lost with it, movement which does not have its origin in a central part of the nervous system, which is excited by the application of a stimuli at the periphery of the organism "from where the impression is transported to the marrow, reflected and returned to the impressed part or brought to a part remote/distant from it in which the muscular contraction takes place." One would be pained to discover anything in this definition of the reflex mechanism that would have not been learned from the ~~lecture~~ of Prochaska. And still neither in the Memoir of 1833, nor in its re-edition of 1837 augmented by a second Memoir *On the true spinal marrow the excito-motory system of nerves*, ~~no~~ allusion is made to Prochaska.

reading
any

Yet, in 1838, the rights of Prochaska to his piece/share of glory are proclaimed and defended, in the course of an exegetic pugilism/fistfight that we summarize based on Fearing (2). One of the presidents of the Society of Medicine of the University College of London, J. D. George, gives lecture to this Society of a study on *The history of the nervous system*¹⁰, of which the conclusion is that Hall took a great part from his predecessors, from Prochaska especially. Comparing point for point the "discovery" of Hall and its probable sources, George establishes that Hall had forerunners on [the] following points :

(1) J. Müller recognized graciously the priority of Hall, for if the Memoir of HALL was published in 1833, as his own *Handbuch der Physiologie* (February 1833), the lecture of the first note of Hall in front of the Zoological Society of London took place on the 27th of November 1832 (cf. *Handbuch*, I, p. 609). HALL coldly acknowledged^{*} took notice of this recognition in an article : On Professor Müller's account of the reflex function of the spinal marrow. (*Lond. and Edimb. Phil. Mag.*, 1837). — In his thesis, *Recherches critiques et expérimentales sur les mouvements réflexes* (Paris, 1864) Cayrade writes : "Making tabula rasa of the past, without any respect for those who preceded him in this study, Marshall Hall attributes to himself, with a wholly British pride, the glory of this important discovery, allowing not even the illustrious Jean Müller^{*} to participate in it." (p. 30)

(2) *Op. cit.*, p. 136-140.

⁹trans. note : given in French in the original, *La fonction réflexe du bulbe et de la moelle épinière*.
¹⁰trans. note : in French i.t.o., *L'histoire du système nerveux*.

* as is, in the original 134 (see our note elsewhere
on this practice t. c. t. p. 139 n. 7

existence of a principle of movement independent from the will and any cerebral function, seat/location of that principle in the spinal marrow, determination of that movement by the stimulation of the bulb's nerves*, reflection of the sensitive/sensory impression in the marrow towards the muscles, utilization of that principle in the explanation of synpathies, of the fetus' movements, convulsive maladies. In his conclusion, George declares that if one made more lectures, less discoveries would be found. The Memoir of George is published in the *London Medical Gazette* in multiple articles (1). In the course of this publication, the same periodical published an Editorial entitled : The reflex action, an old discovery (2). There the claim is made that Hall was completely beaten to it by Prochaska and the insinuation that one is dealing with a plagiarism skillfully/adroitly dissimulated. And the following fact should be proof enough : an edition of the works of Prochaska is located at the Library of the Medical and Surgical Society ; but this work, little known by readers, was manifestly appreciated by at least one member of the Society who borrowed it on multiple occasions and who is no other than the Dr Hall. We witness then a singular spectacle. Hall demands and obtains from the librarian of the Medical and Surgical Society an attestation according to which he borrowed the work of Prochaska in 1835 and in 1837, which is to say posterior to 1833 (3). However we will note that neither the re-edition of the Memoir, nor the second *Memoir on the excito-motory system*, in the year 1837, contain the name of Prochaska. It is only in a publication of 1850 (4) that Hall explains himself regarding Prochaska. There he observes that he cited Redi, Whytt and Legallois, in his first Memoir, as having done experiments analogous to his own, but he remarks that these experiments did not lead to any result, to no explanation in the domains of anatomy and of physiology or of diagnostic or of therapy, that Whytt was mistaken when explaining the reflex action through a psychic principle even though it is a physical principle,

space

(1) Contribution to the history of the nervous system, *London Med. Gazette*, 1837-38, XXII, p. 40-47 and 93-96.

(2) Intemperance of Medical Controversialists. Reflex function, an Old Discovery, Editorial, *Lond. Med. Gaz.*, 1837-38, XXII, p. 72-73.

(3) Letter to the London Medical Gazette including Letter from Librarian of Med. Chir. Soc. Editorial Replay, *Lond. Med. Gaz.*, 1837-38, XII, p. 180.

(4) *Synopsis of the diastaltic nervous system*, London, 1850. The word *diastaltic* is invented by Hall to designate everything that is related to the reflex centers and functions. A definition of it can be found in the *Dictionnaire* of LITTRE : "Action diastaltique ..." / "Diastaltic action, group of acts entailing the sensitivity in the sensory/sensitive nerves, the reaction from the nervous centers and the motor or excito-motor transmission to the muscles (when this transmission is not accompanied by a sensation it corresponds to the reflex action)."

* nerfs rachidiens

that Unzer was mistaken in taking the marrow for a bundle of nerves coming/stemming from the brain, which excludes the diastaltic action of the marrow, and that Prochaska, disciple of Unzer, did not make less confusions than his master.

Grafted onto this painful and humiliating incident is another, also reported by Fearing, based on the testimony of Hall's widow (1), and where the burlesque fights it out with the dramatic. The second Memoir of Hall in 1837, had been refused by the Royal Society. Hall addresses a letter to the members of the Council demanding from them that a committee be nominated who would testify of his experiments, examine the conclusions that he draws from them, critique his memoir before condemning it. A passage from this letter gives an idea of the tone of the polemic: "While I did take from Whytt the narrative/story of an observation by Redi of the movements of a decapitated turtle, someone asked if turtles are still alive when one makes a soup of them. Such a question calls for no remark on my part. It is more a rudeness/insult addressed to the Royal Society itself." According to Mrs Hall, the request of her husband was met with a contemptuous silence (2). Fearing ends the story of this polemic by saying that the exact appreciation of Hall's works is rendered difficult by the tendency he had to exaggerate the originality of his own contribution (3) and finds support, on this topic, in the opinion of Eckhard and Sherrington (4).

over
re-used
(alterh.)

In a recent study, Sir Geoffrey Jefferson evokes again the polemic, examines anew the soundness of Hall's pretensions to complete originality, reports the critical judgments of the contemporaries of Hall, Todd and Grainger, and concludes about the necessity to overcome, in order to judge Hall equitably, the antipathy that his vanity inspires (5).

It is in the follow-up to these polemics that the Pedagogical treatises of physiology, posterior to the first publications of Hall and Müller, mention Prochaska in the first ranks of

(1) Charlotte HALL, *Memoirs of Marshall Hall by his widow*, London, 1861.

(2) Cf. FEARING, *op. cit.*, p. 138.

(3) *Ibid.*, p. 138.

(4) *Ibid.*, p. 139. Eckhard judges that the comparison between Hall his predecessors leads one to think that the personal contribution of Hall to the study of the reflex was greatly exaggerated. *Ibid.*, p. 140. Sherrington says that he couldn't see any real difference between the conception of Hall on the decapitated animals and those of Whytt, Hale, Prochaska and even Descartes. Quote borrowed from STIRLING, *Some Apostles of Physiology*, London, 1902, p. 86.

(5) Marshall Hall, the Grasp reflex and the diastaltic spinal cord, in *Science Medicine and History, written in honour of Charles Singer*, vol. II, Oxford University Press, 1953, p. 303-320.

authors cited as precursors in the study of reflex movements. In France, from/as soon as 1842, Longet defends ardently the thesis of the priority of Prochaska over Hall, in his *Traité d'anatomie et de physiologie du système nerveux* (1).

In 1853, in Germany, E. Pflüger (1829-1910) cites Whytt, Legallois, and very abundantly Prochaska, in the historical notes of the first chapter of his work *The sensory functions of the spinal cord in the vertebrates*¹¹. This important work in which are formulated the laws that remained long classic of the reflex (unilaterality, asymmetry, irradiation, generalization) did a lot to accredit the conception according to which the reflexes are reactions, fixed, rigid, uniform, and through this fully assimilable to mechanical effects. But those who, underestimating the critiques of Richet, of Sherrington, of Lapicque relative to the rigidity of the sensitivo-motor liaison/link, continue still to teach the laws of Pflüger, seem to ignore that this author, involuntary father of a mechanist reflexology, thought that the final reason of the modalities of the reflective reaction, was a sort of medullary consciousness of the goal to be attained by/through its mean. From this viewpoint, Pflüger was the intellectual contemporary of Prochaska. And that is why, in the preface of his work, he declares : "Prochaska, in the preceding century, has very well understood, better than Marshall Hall, what has been called after him the reflex process (*den bereits von ihm so benannten Reflexprozess*)¹². Pflüger highlights / brings out well, among others, that the notion of reflex is, in the XVIIIth century, a piece of a teleological conception of the organic life (2).

In 1856, in his lessons of the Collège de France on *La physiologie et la pathologie du système nerveux* (3), Claude Bernard speaks of the conceptions of Willis on the nervous fluid but only sees in it a deprecated theory, and without making allusion to his ideas on the reflex movements (December 17th lesson) ; in 1857, dealing with the reflex movements, he names Prochaska at the head/top¹³ of those who had studied it (February 20th lesson).

(1) T. I, Paris, 1842, p. 307 sq. LONGET takes up again this thesis in his *Traité de physiologie*. In 1869, he writes in the 3rd edition of that work : "It has been almost thirty years since I published for the first time, in t. I of my *Traité d'anatomie et de physiologie du système nerveux*, the historical overview¹⁴ that precedes. Since that time/epoch various authors have reproduced it almost textually/literally/verbatim without indication of its origin" (t. III, p. 245). In that latter work the historical overview of the reflex is found p. 239-245.

(2) *Die sensorischen Functionen des Rückenmarks der Wirbeltiere nebst einer neuen Lehre über die Leitungsgesetze der Reflexionen*, Berlin, 1853, p. VIII-IX and p. 1-14.

(3) Published in 1858, Paris, J.-B. Baillière.

¹¹trans. note : French i.t.o., *Les fonctions sensitives de la moelle épinière des vertébrés*.

¹²trans. note : either C. paraphrases and extrapolates or makes a translation error. Faithful translation is : what he had already named thus reflex process. d

¹³trans. note : tête (head) is almost certainly use purposefully here; or a fortunate accident/coincidence...

¹⁴trans. note : l'historique. The easiest, but lossy, translation is : history. However since the term histoire is also translated by history, and the title of the chapter contains both terms, the easier isn't really the best. Depending on context l'historique can be a history ; it can be a historical overview ; it can be a historiography in combined form.

It could also be a philosopher's way, by turning into a noun, to refer to the historical nature of things... (see the former, n. 46 of p. 37)

It's in 1858 that a new polemic, provoked this time by the growing amplitude of Prochaska's reputation, leads to the apparition, for the first time, of the name of Descartes in the history⁴ of the reflex. The occasion for it is given/provided by an article of A. L. Jeitteles, professor at the Faculty of Medicine of Olmütz, *Who is the founder of the theory of reflex movements*⁵ (1) ? Jeitteles summarizes the first memoir of Hall, says some words on the question of the ~~propriety~~ ^{priority} of Hall over Müller, recognizes the great value of their works, but declares that the impulse for researches on reflex action come from elsewhere, from before and from another. "It is none other than our eminent and today still too little honored compatriot, Georges Prochaska, who merits well that our Czech homeland, so rich in superior men of all kinds, conserves him in its eternally grateful memory." Jeitteles affirms that Prochaska is the authentic founder of the theory of reflex movement, cites extracts of *De functionibus systematis nervosi* and concludes that the whole theory of reflex activity proper/specific to the marrow is already found there preformed and pre-established (*präformirt und prästabiliert*). Without wanting to research if Hall and Müller, although they may not have directly known the works of Prochaska, were not influenced by what could have transpired in the scientific milieu/environment of contemporaries and of epigones/followers (*in die gleichzeitige und epigonische Wissenschaftliche Welt transpirierte*), Jeitteles asks himself how these works could have remained unknown/badly understood⁶ for so long. He thinks, and that seems very judicious to us personally, that the prestige and authority of Haller are sufficient to explain it. The theory of irritability, force inherent to the muscle, had for effect to draw/take the attention away from the functions proper/specific to the spinal cord. This makes only more sensible the merit of Prochaska. His theories do not summarize the ideas of the epoch, they contradict them. Last lines of the article are an appeal to the generous historian who will revive, as a model for generations to come, the figure of the great Prochaska. Jeitteles wishes that it be the current holder of the chair of Prochaska at the ancient and famous University of Prague, "valiant forerunner of all the other German universities". Meant is the illustrious physiologist Purkinje (1787-1869).

The impetuosity of this plea, where the claim of originality of a scientist/scholar is allied, naturally and pathetically, to

(1) Wer ist der Begründer der Lehre von den Reflexbewegungen? in *Vierteljahrschrift für die praktische Heilkunde* (hg. von der medizinischen Facultät in Prag), 1858, Band IV, p. 50-72.

eventually: published by the medical Faculty Book in Prague

merge w
the
previous note
(p 137)
n. 14

⁴trans. note : l'historique. On the usage of this term : l'historique is also used, it seems, in a -typically philosophical fashion as a noun to refer to the historical character of something.

⁵trans. note : i.t.o., *Qui est le fondateur de la théorie des mouvements réflexes*.

⁶trans. note : méconnus, ≠ inconnus, not unknown, but poorly known with the connotation of poorly understood also.

the affirmation of the values of the culture of an oppressed nationality, has for equal only the brutality and the insolence of the reply that is given by an official representative, to not say a pontiff, of the German physiology. Émile Du Bois Reymond (1818-1896), the student and successor of Johannes Müller⁷ at the chair of physiology of the University of Berlin, already famous for his works in neuro-muscular electrophysiology, but also his multiple philosophical confessions of faith⁸ professions in the universal validity of mechanist determinism and in the inanity of metaphysical questions (1), summarily executes Prochaska and returns to Descartes the honor of having as a genius anticipated, in matters of reflex, the word and the notion. In his commemorative discourse, on the occasion of the death of Müller, in 1858, Du Bois Reymond declares having found (*wie ich gefunden habe*) that Descartes, approximately a century and a half before Prochaska, has described correctly the reflex movement (*erstens beschrieb... Descartes... die Reflexbewegungen völlig richtig...*), that he used the same analogical image (reflection) and that the law of peripheral manifestation of sensible impressions is owed to him just the same (2). One can tell, in the passages of the talk that precede and follow lines about Descartes, what the intention of Du Bois Reymond is. It is first to secure ^{the} copyright/the rights of author, if we dare say, of Johannes Müller, who could have ignored Descartes but not Prochaska. If Prochaska is not the father of the reflex notion, he falls himself under the blow of judgment that one could strike in his name over his successors. Moreover, Descartes is according to Du Bois Reymond a conscious mechanist physiologist, theorician of the animal-machine, to whom should go the same admiration as La Mettrie, theorician of the man-machine (3) ; whereas Prochaska is a fuming and inconsequential mind for whom the notion of reflex is tied to that of *consensus nervorum*, anatomic myth of animist inspiration (4), to the point where if Prochaska formulated in 1784 the principle of reflection of sensory impression, he does say a word of it in 1820 in his *Physiologie oder*

breath
not

(1) We know the conclusion : *Ignorabimus !* of his discourse *Über die Grenze des Naturer kennens* (1874).

(2) Gedächtnisrede auf Johannes Müller, in *Reden, Zweite Folge*, Leipzig, 1887, p. 204. This discourse/talk was published for the first time in 1859 in the *Abhandlungen der Akademie der Wissenschaften* (Berlin).

(3) Cf. a talk of DU BOIS REYMOND on La Mettrie, *Reden, Erste Folge*, Leipzig, 1886, p. 178. — Du Bois Reymond certainly did not forget that La Mettrie had sought and found asylum, in 1748, at the court of Frederick II.

(4) Du Bois Reymond does not clearly see / misunderstood what Eckhard will perfectly glimpse, the relation between the problem of sympathies and the problem of reflexes.

⁷trans. note : "Jean Müller", in the original. (We find this practice repugnant. Soury does the same to e.g. Goltz.)

⁸trans. note : here the expression of "philosophical confessions of faith" is used in a manner that is not without recalling Engel's own, also always humorous, *Draft of a Communist Confession of Faith* (fittingly another text from the mid 19th c.).

Lehre von der Natur des Menschen (1). To conclude, Prochaska did not know what he was doing when he got the occasion, for the first time, to describe correctly the reflection of sensory impressions. Among contemporaries, the only author of whom one could affirm with validity the ~~propriety~~ over Müller, is Marshall Hall and it would be a priority of two months (2). It is likely, finally, that Du Bois Reymond aims to, in reducing Prochaska, to depreciate a school of biologists manifestly guilty, in his eyes, of metaphysical sin, the school of Naturphilosophie.

priority

In the *Reden II*, of 1887, the discourse of 1858 is published with explanatory/clarification notes. Those that concern the texts of Descartes which Du Bois Reymond founds himself on are particularly precious to us (3). Talk is of article 13 of *Traité des passions* where the palpebral reflex is described. We should remark that Du Bois Reymond makes no difference between a description and a definition, and it is pushing dishonesty a little far to reproach, in this note, to Prochaska to have used the same example as Descartes. One would make laugh by supposing that Sherrington couldn't have, other than borrowing it in Willis, picked as reflex of study the scratch-reflex⁹. Besides Prochaska was an ophthalmologist, and could, at a push, do without Descartes in order to know that there exists an involuntary occlusion of the ~~propres~~ eyelids (4) ! The second text of Descartes invoked by Du Bois Reymond is article 36 of *Traité des passions* which we have cited and analyzed in its time, and of which we said that if it did indeed contain the expression of *esprits réfléchis* [t.n. reflected spirits], this appellation, unique in the works of Descartes, is utilized to explain the mechanism of a behavior which is not properly speaking a reflex. If truly, based on the word of Du Bois Reymond, Prochaska did not know what he was doing by treating over many pages, in his *Commentatio* of 1784, of the reflection of sensory impressions into motor ones, what should be said, in virtue of the same principle of appreciation, of an author who only makes use once of two words?

Before Du Bois Reymond, J. W. Arnold had, in 1842, in his book *The theory of the reflex function for physio*-¹⁰

(1) We were not able to consult this work ; but we have already noted that PROCHASKA does use the concept of reflection in his *Physiology* of 1797. V. *supra*, p. 121, n. 2.

(2) *Reden*, II, p. 205.

(3) *Ibid.*, p. 317.

(4) According to Fritz LEJEUNE, *Leitfaden zur Geschichte der Medizin* (1943), p. 123, Prochaska is supposed to have done over 3.000 operations of the cataract.

⁹trans. note : between quotation marks i.t.o. (unneeded here).

¹⁰trans. note : i.t.o., *La théorie de la fonction réflexe à l'usage des physiologistes et des médecins*.

logists and doctors (1), given a summary but precise history of the precursors of Mr. Hall, in which he cited Unzer, Whytt and Legallois, the first for having used the term of reflection, the others for having established the facts to which the notion convenes. But he did not cite Prochaska. He questioned the motives of the choice of the term of reflex, choice that neither Hall nor Müller had justified, and which to him seemed to be naturally founded on the assimilation of the nervous phenomenon with the phenomenon of the reflection of light (2). But especially it is because in one passage of this work he is conducted to cite Descartes that we talk about it here. Arnold brings Descartes and Müller near, by referring to the text of the *Treatise on Man* where the mechanism of the body is compared to organs (3). However this passages provides Eckhard with the occasion to write in his excellent *Evolution of the theory of reflex phenomena*¹¹, in 1881, that Arnold first and Du Bois Reymond later made justice to Descartes regarding his contribution to the theory of reflex (4). But by reediting in 1887 his discourse of 1858, Du Bois Reymond contests his pretended debt towards Arnold and makes observe that in the passage targeted by Eckhard reflexes are not in question, but talk is of the theory said of the piano, exposed by Müller, and which Arnold with great pain tries to follow back up to Descartes (5).

We leave thus to Du Bois Reymond, on his demand, the sole responsibility of his historic discovery. If we entered the details of this controversy, it is because it enables us finally to establish with precision the origin of the commonly admitted opinion, that sources to Descartes the paternity of the name and a sketch of the notion of reflex, opinion of which Fearing, as we saw, makes himself on multiple occasions the echo, but on the formation of which, we said, he never interrogated himself (6).¹² And, at the same time as his origin, we hold the direction/meaning of this assertion. As for the circumstances in which it is pronounced, the discourse of Du Bois Reymond tends to

(1) *Die Lehre von der Reflex Function für Physiologen und Aerzte*, Heidelberg, 1842.

(2) *Op. cit.*, p. 49.

(3) *Ibid.*, p. 60-61. Arnold refers to the *OEuvres* of DESCARTES published by Victor COUSIN, IV, p. 334.

(4) *Geschichte der Entwicklung der Lehre von den Reflexerscheinungen*, *op. cit.*, p. 34.

(5) *Reden*, II, p. 318, n. 90. — The theory said of the piano is an explanation proposed by Müller concerning the distribution of motor excitations from the cerebral origins of the nerves.

(6) Neither in this text, nor in the bibliography, does Fearing's book make mention of the *Discourse* of DU BOIS REYMOND.

¹¹trans. note : i.t.o., *Histoire du développement de la théorie des phénomènes réflexes*.

¹²trans. note : obvious reference to the debates that took place in chapter 2.

(Arnold p.37)

recall to order a Czech professor too little convinced of the superiority of Germanic civilization. As for its scientific reach/scope however, that same discourse proceeds, in the thought of a physiologist for whom scientism holds place for a philosophy, from the concern with finding again, in the supposed Cartesian pre-sentiment of a discovery which begins to sustain a mechanist interpretation of psycho-psychological phenomena take in their entirety, a guarantee and as if an authentication of the exploitation that is disposed to make of it. It is less for reasons of pure physiology than for philosophical reasons that Descartes is crowed a great physiologist and illustrious precursor. Here there is a significant example of a certain way of writing history that Émile Bréhier characterized so well : "The search for influences or the search for sources was understood, in the entirety of the second half of the XIXth century, in the mechanist sense usual of the spirit of this epoch ; it was all about finding in a near past the elements whose addition or synthesis formed the studied doctrine ; at a push, one could almost exclude the duration (1)". We think we ought to anger no one by saying that after Du Bois Reymond the historical overviews of the reflex that can be read in physiology treatises are in general copied one from the other, and that when Descartes from now on finds a place in them, it is for the sufficient reason that someone else had first put him there. That being said, our intention is not to diminish the authority of the physiologists, for we know that their merits are due to works other than history. We do not have the ambition to recall all such historical overviews, we propose less to do a compilation than the highlighting of certain significant positions.

The name of Descartes however is never cited in the theses of J. Cayrade, *Recherches critiques et expérimentales sur les mouvements réflexes* (1864) (2), whose 27 first pages are dedicated to the historical overview of the question. Cayrade retraces the history of the problem of sympathies and links it to the history of the reflex from Astruc onward, of whom he says that it is in his theory that appears for the first time the word of reflection in 1743. He notes that Whytt recognized first that the spinal cord enjoys the same prerogatives as the brain when it comes to sensation and movement. He thinks that Prochaska did nothing else than develop the program proposed by Whytt and that Longet was mistaken in claiming for Prochaska the priority in the formation of the concept

(1) *La philosophie et son passé*, Paris, 1940, p. 7.

(2) Thèse de Médecine, Paris, 1864.

of reflex (1). He signals the importance of the experiments of Legallois inasmuch as they established that each segment of the spinal cord enjoys the same properties that Whytt and Prochaska had recognized in the spinal cord as a whole (2).

In 1866, however, Vulpian, takes up again, in his *Leçons sur la physiologie générale et comparée du système nerveux*, Longet's opinion on the rights of Prochaska to priority (3). He also cites the works of Whytt and of Legallois. If he speaks of Willis, it is only on the subject of the cerebellum. He concludes : "We see that the reflex phenomena had been studied before the works of Marshall Hall and of Müller. But they had yet not taken rank inside the classical teaching of physiology and one could even say that we did not have a very clear idea of their importance before these two authors (4).

In 1876, H. Beaunis, in his *Nouveaux éléments de physiologie humaine*, cites the work of Prochaska (*Commentatio...*, 1784) at the top/head of the bibliography that he raises concerning the reflex action. In 1888, in the 3rd edition of his book, he declares more clearly that Prochaska submitted as the first the reflex phenomena to a thoroughly scientific study, and he cites him again at the top/head of his bibliography which entails, the thesis of Cayrade (5).

It is only in 1878, twenty years after the discourse of Du Bois Reymond, that a French author cites for the first time Descartes as one of the precursors of the theory of reflex actions, and that author is a physiologist, H. Milne-Edwards. One must note that in his book on *Le principe vital* (1862), Francisque Bouillier, known for his *Histoire de la philosophie cartésienne* (1854), does not say a word on the Cartesian theories of muscular movement and functions of the nerve, at the same time as he reproaches to Descartes to have identified life with a sum of movements. It is true that Bouillier is a disciple of Victor Cousin¹³, and this explains that. It is also to Victor Cousin that the Dr Bertrand of Saint-Germain dedicates his book *Descartes considéré comme physiologiste et comme médecin* (1869). This book does not contain a word on the reflex, even though it contains a fairly surprising passage wherein Descartes is presented a precursor

(1) *Op. cit.*, p. 19.

(2) *Ibid.*, p. 23.

(3) *Op. cit.*, Paris, G. Baillière, p. 395.

(4) *Ibid.*, p. 397.

(5) Paris, J.-B. Baillière, p. 321, for the 1876 edition ; Paris, J.-B. Baillière, t. 1, p. 668 and 675, for the 3rd edition of 1888.

¹³trans. note : mighty administrator of the French education system, with a disproportionate influence on its orientation, content. These fairly obscure aspects of XIXth century French philosophy and education, and the "this explains that" pique are explained p. 144; i.e. the disregard for entire parts of Descartes' oeuvre under the impact of the same Cousin - also one of the editors of Descartes' works.

V
(ie. the scientific / medical parts, presumably)

of cellular theory (1). We admit, very sincerely, that all taken, the opinion according to which Descartes is one of the founders of the theory of the reflex appears to us better backed up/fleshed out. We should highlight, by the way, that it is the physiologists who have relayed the philosophers all the while the latter, under the influence of Cousin's spiritualism, for their exclusive attention to the first five of the *Meditations metaphysiques* paid in distraction with regard to the 6th, the *Traité de l'homme* and the *Traité des passions*.

Here is the passage that H. Milne-Edwards dedicates to Descartes : "In our schools of physiology, the discovery of nervous reflex actions is often presented as being of recent date. Nonetheless, from the middle of the XVIIIth century, our great philosopher Descartes had glimpsed the essential character of certain phenomena of the same order : his remarks, it is true, were only applied to automatic sensory movements and the images that he used to render his thought are not in accordance / do not agree with our current ideas, but he had a strongly/very clear conception of the relations that can be established in the organism between a sensory nervous impression and an excito-motor influence, because he explains through a kind of repercussion of the nervous force, force which he designates under the name of animal spirits, the involuntary closure of the eyelids at the sight on an object that is close to touching our eye (2)." Milne-Edwards cites in a note that same article 13 of *Traité des passions* that Du Bois Reymond, we saw it, appealed to first in order to support his thesis. Did Milne-Edwards, in 1878, have knowledge of the discourse in honor of J. Müller? It is possible since the text was published for the first time in 1859. In any case, in the re-edition of 1887, Du Bois Reymond cites Milne-Edwards and Charles Richet as French authors who recognized, after himself, the importance of the ideas of Descartes (3), but he reproaches to them to have neglected the second of the Cartesian texts indicated by himself, [the] article 36 of *Passions de l'âme*. We see however how much the judgement of Milne-Edwards is more nuanced than that of Du Bois Reymond and that, under the reservation of the words : "He explains through a kind of repercussion of the nervous force, etc." — for indeed, in the Cartesian schema, the animal spirits,

(1) *Op. cit.*, Paris, V. Masson, ed., p. 376. The author refers to a passage of the *Manuscripts* of HANOVER published by FOUCHER DE CAREIL. Cf. *Generatio animalium*, A.-T., XI, p. 534 : *In eo convenit formatione plantarum et animalium quod flant a partibus materias vi caloris in orbem convultae*.

(2) *Leçons sur la physiologie générale et comparée du système nerveux*, t. XIII, Paris, Masson, 1878-79, p. 112-113.

(3) *Reden*, II, p. 318, n. 90.

playing no role in the phase of sensory conduction, wouldn't know in any way to reflect¹⁴ — we can subscribe to this appreciation. We must note, in particular, that Milne-Edwards calls sensory automatic movements the movement described by Descartes. In his language, the sensory movements are inducted automatic movements that suppose a conscious perception (sensation/feeling) of the sensitive excitations through the excitomotor center, whereas the reflexes are induced and unconscious automatic movements "without the intervention of any force of mental origin" (1). We understand from then why he does not cite the article 36 of the *Traité des passions* that Du Bois Reymond reproaches him to have neglected. Milne-Edwards seems to have understood that, properly speaking, the reflex is not in question in that passage of Descartes. Let us say finally that, ~~among the precursors of Marshall Hall and of Müller~~, Milne-Edwards cites Astruc, Whytt, Unzer and Prochaska. Is he more ~~general~~ or better informed than Du Bois Reymond? In any case, he must have found the reference to Astruc in the thesis of Cayrade which he cites on multiple occasions (2). general

The historical memoir that is the most complete, the best informed by far, is the work of C. Eckhard, *Evolution of the theory of reflex phenomena*¹⁵ (1881). Eckhard glimpses very clearly the link between researches relating to reflexes and the medical studies on sympathies. He cites Descartes, conforming to the observations of Arnold and Du Bois Reymond, as the first precursor of the theory of the reflex, as the one who should have as the first even employed the verb "réfléchir" [t.n. reflect] in order to give an account of the mechanism of this type of movement. Eckhard is the first to recognize the importance of Willis, not only for his observations, but for his conceptions that are fairly close¹⁶ to modern ideas (3). He notes that Willis places in the encephalon the seat of reflection, but seems to have admitted that connections of sympathy could take place at the level of the peripheral anastomoses of the nerves. Eckhard admires Whytt much, cites rapidly Astruc based on Cayrade, grants little importance to Unzer and extends at more length about Prochaska of whom he finds that Longet and Jeitteles have overestimated

(1) *Op. cit.*, p. 109-110.

(2) *Ibid.*, p. 113-115. — On CAYRADE, cf. p. 134, 138, 154.

(3) Geschichte der Entwicklung der Lehre von den Reflexerscheinungen, in *Beiträge zur Anatomie und Physiologie*, vol. 9¹⁷, Giessen, 1881, p. 36 : *Er war nicht allein mit vielen ächt reflectorischen Bewegungen bekannt, sondern spricht sich auch über ihre Entstehung in einer Weise aus, welche den Gegenwärtigen Vorstellungen sehr nahe kommt.*

¹⁴ [t.n. répercuté]

¹⁵ trans. note : *Histoire de l'évolution de la théorie des phénomènes réflexes*, i.t.o..

¹⁶ trans. note : *assez proche* is falsely attributed to Eckhard who writes, on the contrary, *sehr nahe kommt* i.e. come very close (to contemporary conceptions).

¹⁷ trans. note : "9te Band", i.t.o., possibly an oversight / error. In the original there are regular occurrences of such small inconsistencies.

space

the importance. He reproaches to him mostly to not have added to the question of reflex movement any experimental contribution comparable to that of Whytt. He at last arrives at the contemporary epoch/period, analyzes at length the work of Marshall Hall, makes an allusion to the polemic directed against him and finally sides with the opinion of J.D. George, following which the reach of Hall's works have been exaggerated. The lengthy history of Eckhard is as moderated as it is documented. It truly is the first fundamental work on the question.

But the best history in the French language concerning the researches on the reflex is undeniably/indisputably, in the XIXth century, that given, in 1882, by Charles Richet in his *Physiologie des muscles et des nerfs* (1) ; he is also the ~~first~~ first who makes explicit mention of the works and ideas of Thomas Willis. Richet makes the remark that the concept of reflex belongs to a kind of biological concept slowly matured :

"The discovery of reflex actions is not, like that of the circulation of blood or of the chemical phenomena of respiration, due to the genius of one single man. It was done gradually, not felt, so to speak ; and the birthing of the actual theory took a long period of time, which is to say about two centuries (1630 to 1830). Descartes had conceived the mechanism of reflex action but he had in all likelihood hardly done much experimentation nor precisely described the seat of reflex movements. Many years later, Willis pronounced the first the word of reflection (2)." *

Having reminded of the experiments of Redi and of Swammerdam on decapitated reptiles, those of Whytt on the frog, conceptions of Astruc and of Unzer, Richet writes that Prochaska is the first to have formulated a general theory of reflex actions thanks to his synthetic spirit, which enabled him to systematize the whole of acquisitions of his predecessors (3). For the first time, in a French scientific work, one can read a documented comparison of respective contributions of Descartes and of Willis. Richet cites, after Du Bois Reymond and Mihe-Edwards, [the] article 13 of Treatise of passions and adds : "Let's suppose now that we replace the old word : *animal spirits* with the word

(1) Paris, Germer-Baillière, 1882.

(2) *Op. cit.*, p. 659.

(3) *Ibid.*, p. 660-61.

* trans.note: Canguilhem gives a precise figure of 163 years, in the conclusion (for "the notion of reflex").

wholly modern and just as obscure : *nervous influx* and the paroles of Descartes could be textually written by one of us to explain the reflex action. Let's be honest : we don't know more than Descartes (1)." Laudable humility, on which we would only make reservations as it drove Richet away from a complete and critical reading of the physiological oeuvre of Descartes, reading that would have taught him that the animal spirits play no role in the phase of centripetal transport of a sensory excitation. But we are more grateful to Richet for having published the profound reason for which Descartes has taken his place from now in all the histories of the reflex : "Modern physiology is wholly mechanist. In that sense, we are all more or less Cartesians (2)." Above all we admire the finesse and equity of a judgment that knows to distinguish, in matters of scientific merit, between an intellectual stimulation and an effective research, and that recognize in Willis the author who, from Galen to Charles Bell, has done the most for the physiology of the nervous system (3). "Descartes conceived it [the reflex action] the first ; but after him, Willis had of it a clearer idea, and he even made use of the expression, *reflexus*, reflex, that we adopt today (4)." Judgment for which Richet finds support in the passage of the *De motu musculari* that we have reproduced and commented (5).

We could not keep silent on the famous historical and critical work of Jules Soury on *The central nervous system* (1899) (6), even though the theories on the functions of the encephalon have there much more space than the theories on the functions of the spinal cord, and considering especially that no presentation in it is specifically dedicated to the reflex. But on one hand it is possible to reconstitute a historical overview of works and conceptions relating to the question, thanks to the incidental notes that he never fails to dedicate to them; on the other, the energetic materialist conviction¹⁸ of J. Soury never lead him to depreciate the contributions of authors who have no place in the Pantheon of the mechanists. He admires Descartes, but he does not admire

(1) *Ibid.*, p. 506.

(2) *Ibid.*

(3) *Ibid.*, p. 507.

(4) *Ibid.*

(5) Cf. *supra*, p. 67.

(6) Le système nerveux central. Structure et fonctions, *Histoire critique des théories et des doctrines*, Paris, Masson, 1899. — Jules Soury, docteur es lettres¹⁸, was director of studies at the Ecole pratique des Hautes Etudes (Histoire des doctrines de physiologie psychologique contemporaine / History of the doctrines of contemporary psychological physiology).

Space

¹⁸trans. note : doctor in the humanities, as opposed to, in the traditional division, sciences.

any less Willis and, different from Du Bois Reymond, does not believe himself forced to mock Prochaska because he still located the *sensorium* in the spinal marrow [cord] (1). Soury says that Descartes "recognized the elementary, primordial, simple act of the central nervous system, the reflex action, and distinguished that movement from other movements" (2), which is a well measured judgment, as much as precisely that recognizing and distinguishing a phenomenon is still not [the same as] defining the concept. Of the judgment passed on Willis, we can regret all the more that it is not complete as it contains all that would be required for it to be : "The reflex action, the word and the thing, have been clearly observed and described by Willis : *Motus est reflexus qui a sensione praevia dependens illico retorquetur* (3)." One does not describe a word, one repeats it or invents it — which is the case here — and when one follows it up with a proposition, one enunciates the comprehension of a concept. As for Prochaska, his originality comes from his power of generalization : "It goes without saying that Prochaska did not the first speak of the reflection in[side] the nervous centers, phenomenon explicitly described not only by Descartes and by Willis, but often observed by all the ancient and modern physiologists under the name of movement of reflection. The notion of reflex action is as old as the physiology of the marrow and of the encephalon : the general theory of this order of phenomena belongs solely to Prochaska (4)." One should be careful with/distrusting of notions as old as the scientific world of which they are a part. Even in mathematics, a notion must engage the responsibility of its author or of its authors, and a responsibility is dated.¹⁹

(1) On DESCARTES, cf. *op. cit.*, I, p. 371-402 ; on WILLIS, cf. *ibid.*, p. 428-442 ; on PROCHASKA, cf. *ibid.*, p. 465-473.

(2) *Ibid.*, p. 371.

(3) *Ibid.*, p. 434.

(4) *Ibid.*, p. 468.

¹⁹trans. note · sounds a lot like Cavailles.

[...]

This notion of reflex action would have a surprising privilege over ~~the~~^{other} physiological notion^s of no less importance, circulation of blood or internal secretion. There can't be, in science, notions as old as things whose birth had no witness. There can be solid notions of always, resistant from their apparition onward, but they did have a beginning, which is to say that they carry a name. Such is the case of the circulation, which carries the name of Harvey. One can without a doubt speak of observations as old as Man, and those that concern the phenomena called reflex in the XIXth century, thanks to an author of the XVIIth, are a part of them. And indeed, if the distinction of voluntary movement

and of involuntary movement has become a problem of physiology, it is due to the importance that it draws first from its religious, moral and legal significance. Before becoming a scientific problem, it is a question concerning the experience of culpability and of responsibility. For example, Aristotle is not only the author who seeks in his treatise *On the movement of animals* a criterion for the distinction between voluntary and involuntary movements, he is also the one who conducts that same exam relating to voluntary and involuntary acts in *Nicomachean Ethics* (III, chap. I), since being unable to define the power and the limits of will, he could not treat of virtue in general and of courage in particular. We can thus say, without error, that the notion of unreflection is much older than the physiology of the spinal cord. But this physiology only begins to exist as science in the moment where ~~the~~ the unreflected movement is named reflex, without any word play⁵ and through a play of images. In such a way that, reverting the proposition of J. Soury, we must say that it is the physiology of the spinal cord which is, thanks to Willis and his successors, as old as the notion of reflex action.

Besides if the notion of reflex action were as old as the physiology of the spinal cord, it would be a notion of which we should say that it became without labor/work⁶, victorious without combat. It would not have founded its scientific value on the defeat of any preceding illusion. But when Galen and later Whytt conceived of the involuntary movement as a voluntary or reflected movement, automatized, that is rendered unconscious, through habit, they enunciate precisely the theory that the notion of reflex must overcome as its intimate obstacle before it can be constituted. And it is for having overcome that obstacle that Descartes has his part which is not small, but different from that which is generally recognized to him, in the history of the reflex. Real obstacles besides are those that do not fall at once. The one which we have just indicated is not as inconsistent as it subsists ^{still} even after the concept of reflex receives from physiological experimentation and histologic investigation a solid confirmation. It is true that talk is of a philosopher, hence, in the judgment of scientists, retarded. Ravaissan, in the *Philosophical Testament*⁷ which he prepared leisurely in 1899-1900, did not believe there was any need to renounce the essential idea of his thesis on *L'habitude*⁸ (1837), and continued to think that any automatic movement is, at the bottom line, only a reflection mechanized through forgetting. "Before/In front of this capital fact disappears

⁵trans. note : the word play in question must be that of double meaning of "reflection", in the sense of optics or here-used sense, and the common pondering, introspection, — and lack thereof in this context *Case*.

⁶trans. note : labor might be better suited than work here, because it preserves the possibility of a faint sense or implicit parallel with birth-giving. *(further pointing to the head)*

⁷trans. note : *Testament philosophique* i.t.o.

⁸trans. note : *(The) Habit.*

in such great favor today (alter.)

the hypothesis, so favored today, of movements that we call reflex and that would be absolutely mechanical responses of the body organized around impressions and solicitations from outside, movements by which the scientists that make use of it pretend to not only explain the phenomena that we believe involuntary, but seem to nourish the hope of explaining those that pass for wholly or partly dependent on the will (2).⁹ Hence thus, at the same time (1899) when Soury writes, in his good conscience as a mechanist psychologist, that one of the elements of his conviction has the same canonical age as a canon of the physiological science, the ^{older} inverse conviction ~~is~~, no doubt older than Aristotelism itself, continues yet to live in the mind of an eminent French Aristotelian.

more
ancient
(alterh.)

We must now bring attention to a fact of pedagogical character peculiar to France. We said that the historical overview⁹ of Richet is the best in the XIXth century found in a French work. Let us say also that it is the last truly worthy of that name. Afterwards, we witness if not the disappearance at least the progressive extenuation of historical summaries¹⁰ in the elementary treatises or in the manuals. In his *Traité élémentaire de physiologie* (1905) E. Gley reduced to a minimum the history of the reflex. He writes that the first notion of the reflex goes back to Descartes (1640) and that Astruc of Montpellier gave in 1743 a striking definition of it : the reflex is an impression transformed into action. That's all. In fact, one does not find in the dissertation of Astruc the definition that Gley attributes to him and one can ask oneself if there had not been a confusion, because this definition is attributed to Ch. Rouget by Beaunis (2).

It does not belong to us to research here the causes of this near general indifference to the history of questions, in the practice of scientific teaching in France, nor even less to judge. We would be tempted to explain this by the acceleration of research, and the multiplication of publications, and thus by the obligation of being ~~being~~ informed about that immediate past which makes up the substance of current events, at the expense, for lack of the required time, of older works on which current events have already passed

(1) *Testament philosophique*, Paris, Bolvin, 1933, p. 73. — Cf. also the n. 20, p. 125, where Ravaisson designates Vulpian as one of the representatives of the school that he intends to refute in affirming that

⁹trans. note : historique.

¹⁰trans. note : récapitulations historiques.

judgment, either that they condemned, or absorbed them. But then again the phenomenon should be of all countries, which it is not. It is thus that we must signal, in this historical summary, the remarkable pages that J. F. Fulton dedicates to a documentary and critical expose/presentation of the principal theories concerning the muscular contraction and its nervous conditions at the beginning of his work *Muscular contraction and the reflex control of movement* (1926), just as the brief but substantial historical notes that precede each chapter of his treatise *Physiology of the nervous system* (1938) (1). We must equally mention the historical summaries¹¹, exactly documented, that appear in recent re-editions, owed to the care of C. A. Loveatt Evans, of the new classic treatise of Starling, *Principles of human physiology*. It is a sign that in all likelihood one must search elsewhere than in the current servitude of scientific research and teaching for the reasons of a phenomenon, specific to France, highlighted previously. It does seem that what is at hand is a certain conception of the relations of science and its history.

We find no historical overview of the reflex in the work of Sherrington that is classic today, *The integrative action of the nervous system* (1906). The name of Willis is not cited there. That of Descartes is two times, but on the subject of the theory of emotion and the theory of reciprocal innervation. On the other hand, as we already signaled multiple times, Sherrington mentions Descartes and Willis as precursors in the discovery of the reflex in multiple passages of his essay on Jean Fernel.²

A special attention must be granted to the history drawn by J. Lhermitte at the head of *Fondements biologiques de la psychologie* (1925) although it concerns mostly the problem of the correspondence between cerebral functions and psychic life (2). It is presented like an abridged version of the work of J. Soury, but does not ignore Ch. Richet's history. As in the latter, the importance of Willis is highlighted as equal to that of Descartes. But it must be regretted that, due to a superficial reading of Treatise on man or owing simply to the relation of being a second hand summary,

(1) *Muscular Contraction and the reflex control of movement*, Baltimore, Williams & Wilkins, 1926. The historical overview occupies the first 50 pages.

Physiology of the nervous system, Oxford University Press, 1938. This work was translated into French by Ms. CHATAIGNON, with a preface of the doyen Léon BINET, Paris, Vigot, 1947. In this translation, the historical note on the reflex is found p. 53. Fulton there attributes to Unzer the first usage of the notion of reflection, and refers to Fearing for the whole question.

(2) Paris, Gauthier-Villars, 1925, p. 7-24.

¹¹trans. note : sommaires historiques.

the praise is not measured according to the rigor of the accompanying justification [the praise is too strident and the justification that accompanies it too low]. "The group of consecutive defensive reactions to a harmful action is accomplished, according to Descartes, through the shaking of the spirits whose circulation is realized through the tight network of nervous fibers following a fixed and pre-established plan." On the whole, this proposition is not false, but the detail isn't sure. Is it really exact that Descartes conceived a circulation of the spirits (1) ? And do we really get a distinct idea for the fashion in which Descartes conceived the nervous net and its envelop when we write further below : "In the man that sleeps, the conducting pipes relax in such a manner that the shaking provoked by exterior objects are powerless to penetrate up to the brain such as for them to be felt and perceived?" But the pipes that envelop the fibers are only conducting in the centrifugal sense/direction. What becomes relaxed however, according to Descartes, are the small nets that compose the substance of the brain (2). Briefly these anatomo-pyshiological notions too summary to be exact, and which, if we refer to the texts, only concern the cerebral phase of movement, are insufficient, according to us, to sustain a judgment as definitive as this one : "Undeniably, we have here the first demonstration of what should be an automatic act or reflex. The conception of reflex arc belongs neither to Prochaska nor to Marshall Hall, it was born from the genius of Descartes (3)." It is true indeed that Descartes shows — not demonstrates — what could be — and not what is — a structure of automatism.

As for Willis, J. Lhermitte recognizes to him the superiority of his anatomy over that of Descartes, a better sense of the seat of automatic functions, an explicit use of the term reflection. But it seems to us that Lhermitte does not directly know Willis. If he cites for example the scratch reflex, it's based on Soury. Finally, it is mostly the anticipation of the chemical theory of nervous influx through analogy with the deflagration of powder

(1) Descartes does speak of passages that God has left among the nets and where the spirits can be conducted towards the nerves, but this disposition is strictly intra-cerebral. Cf. *Traité de l'homme*, A.-T., XI, p. 192 ; BRIDOUX, p. 866. And without the brain the movement of spirits is not a circulation but an agitation.

(2) *Traité de l'homme*, A.-T., XI, p. 197 ; BRIDOUX, p. 869-70.

(3) *Op. cit.*, p. 19.

which appears "almost prophetic" to Lhermitte. In 1925, indeed, the ideas of Keith Lucas and of Bayliss on the propagation of the nervous influx are well known if not classic. And it is very justly that Lhermitte thinks of them on the subject of Willis.

It is not a historical overview¹² but a long monograph that is the essential work of Franklin Fearing, *Reflex action* (1930) (1). We have nothing special to say about it here, after what we ~~have~~ have already said of it on multiple occasions. We simply mention it by its rank in our chronological review.

We saw that Gley reduces the historical summary of the reflex to two names and two dates : Descartes (1640) and Astruc (1743) (2). Lapicque, in 1930, reduces it to one name and to one date : Astruc (1743), in the *Physiologie générale du système nerveux* which he writes for the *Nouveau traité de psychologie* of G. Dumas (3). In that same treatise, Georges Dumas writes that "Descartes has formulated, based on the facts, the modern conception of the reflex" in a rather lengthy expose on the mechanist theories of Descartes concerning the expression of emotions (4). And even though it might be exiting physiology proper to cite Pierre Janet, we wish to link the opinion of Dumas relative to Descartes ~~with~~ an opinion that appears more just to us and which consists in saying that the elementary automatic movement studied by Descartes "became the reflex act" (5).¹³

(1) Baltimore, Williams & Wilkins, 1926. This book of 350 pages entails a very important bibliography.¹⁴

(2) We ask ourselves to what corresponds, in the work of Descartes, this date of 1640. As for 1743 it is the date that Cayrade assigns to the Dissertation of Astruc. *supra*, p. 98, n. 5.

(3) Paris, Alcan, vol. I, 1930, chap. IV, p. 148. Lapicque justifies, in turn, the choice of the word reflex by the image of the mirror.

(4) *Ibid.*, vol. III, 1933, b. II, chap. I, p. 45.

(5) "Descartes, to whom is attributed the consideration of the thought as starting point for the life of the mind, only spoke of Cogito from the philosophical viewpoint. He was also one of the first to study another phenomenon as primordial when he described in a famous schema a man sat next to a fire who withdraws their hand when it is burned. This elementary movement so well studied by Descartes and Malbranche has become the "reflex act" and an entire psychology has been erected that takes this reflex act for starting point. Griesinger already began to say that all the movements of Man were only complications of the reflex act." *Les débuts de l'intelligence*, Paris, Flammarion, 1935, p. 34. — It is exact that W. GRIESINGER (1817-68), renowned neuro-psychiatrist, in an article : *Über psychische Reflexactionen* (1843, in *Gesam. Abhandlungen*, I, Berlin, 1872), has attempted for the first time to compose all the actions of the soul on the model of the reflex.

Exner, famous Austrian physiologist, has constructed he also a general explanation of all psychic functions based on the reflex, pushing the logic so far as to make of the reflex what we would call an Anti-Cogito ; one should not say any longer, according to Exner : I am, I feel, but : It is thought in me, It is felt in me (*Über allgemeine Denkfehler*, *Deutsche Rundschau*, LVIII, 1889). Cf. J. SOURY, *op. cit.*, II, p. 1072-73.

¹²trans. note : in this passage especially we feel that *historique* calls for historical overview, (or an alternative e.g. summary), more than history, due to the following contrast with "a long monograph".

¹³trans. note : Canguilhem here insists once more on the idea - which is one of the fundamental aspects of *La formation's* argument - that what was derived from Descartes "became the reflex act", as opposed to really being it, in the Cartesian descriptions.

¹⁴trans. note : selective praise of Fearing, as we've alluded to, could be pointed out systematically, we don't, because it would mean descending into depths of scholarly chicanery that we know to be endless. The bibliography may be great, but the content, interpretations of the facts, and much everything else that matters - that battle, which was the real battle, already unfolded during the exegetic k.o. of chapters 2, 3. Here some laurels, actually branches...

* trans note: On general errors of thought / in thinking.

It is still in the German language that appears, in 1938, a lengthy article of Ernst Marx, *The evolution of the theory of reflex since Haller until the second half of the 19th century*¹⁵ (1), which seems far inferior to us, as to content and interest, to Eckhard's article.¹⁶ It only matches up with our study as to what concerns Prochaska. E. Marx makes the honor to the latter of the initial conception of the reflex, but ignoring — fairly unexplicably — the *Commentatio* of 1784 and only referring to the *Lehrsätze aus der Physiologie des Menschen* from 1797, he writes that Prochaska did not use the term of reflection, which is properly inexact as we saw further above. The article contains a digression on the neuro-muscular mechanism of the union of soul and body according to Descartes, but says nothing of a possible relation between the Cartesian mechanism and the theory of the reflex. entails

Let us bring attention still in the *Vocabulaire de la psychologie* published by H. Piéron (1951) to the article relating to the reflex : "The reflex, conceived by Descartes, denominated by Th. Willis (1682), initially experimented by Robert Whytt (1752) is characterized by the tight correlation that makes a response depend on a determined stimulus ; for that reason, it is often opposed to the voluntary act."

One must finish by noting in the lesson of Charles Kayser on *Réflexes et comportement* (1947) a fortunate derogation to the French tendency towards the elimination of the historical in scientific presentation. In the matter of reflex, his history is, in the XXth century, by far the best, as is that of Richet for the XIXth century — for France one understands. As for the article of H. E. Hoff and P. Kellaway, *The early history of the reflex* (1952), of which we discussed some of the conclusions in our second chapter, it reproduces the first of a series of lectures in the history of medicine, given by two professors of neurology at the University of Dallas (State of Texas) to students of medicine. It is, in our eyes, a model of the genre (3).

(1) *Die Entwicklung der Reflexlehre seit Albrecht von Haller bis in die zweite Hälfte des 19. Jahrhunderts*, by Ernst MARX, with a foreword/preface/introduction [Geleitwort] of Viktor V. WEISZÄCKER : in *Sitzungsberichte der Heidelberger Akademie der Wissenschaften*, Jahrgang 1938, 10. Abhdlg, s. 9-126.

(2) Cf. *Bulletin de la Faculté des Lettres de Strasbourg*, 1947, February issue, p. 89-108 and March, p. 133-148.

(3) *Journal of the history of Medicine and allied sciences*, vol. VII, 1952, n° 3, p. 211-249.

¹⁵trans. note : *L'évolution de la théorie du réflexe depuis Haller jusqu'à la seconde moitié du XIXth siècle* in the orig.

¹⁶trans. note : considering that Eckhard's contribution is from 1881, this is both an exceptional accomplishment for Eckhard and a hard blow for E. Marx who has a jump of 60 years on him and still managed to land below... Does this make Eckhard the best historical publication for the 19th and 20th centuries, implied first half, in the German language? The presentation we feel is not fully clear on this, but this would be surprising if so.

*
* *

Circumstances and motives very different from one another give an account of the successive appearance, in the history of the reflex of the names of Descartes, of Willis, of Astruc and of Prochaska, Unzer being generally left in the shadow. The name of Prochaska emerges from a polemic, that opposes multiple living to one living [person]. Marshall Hall, and that turns into what is called vulgarly settling debts/scores. Here we are dealing with a small history of scientific coteries, as the becoming/evolution of science knows oh so many. The name of Descartes arises from a diatribe directed against one dead and with the apparent intention to honor another dead [person]. In fact, at hand is another liquidation of an opposition, and even, when looking from close up, of two. A culture, through the voice of one of its official representatives, defends against another culture its political superiority of the moment. A philosophy of life, enclosed in the frame of a biological research method, treated like a mythology another philosophy, supposed inapt to promote an efficient scientific procedure. Mechanism against vitalism. As for Willis and Astruc, they are the only ones whose rushing forth from oblivion owes nothing to an act of aggression. Cayrade discovers peacefully Astruc while exploring, aiming for a thesis in medicine, the medical literature of the XVIIIth century relating to the problem of the sympathies. Eckhard and Richet finally name Willis, last. However it is that name which should have appeared immediately after the one of Prochaska, whose work redirect⁶ naturally to Willis as to Unzer. But the *Commentatio* of Prochaska was first use/utilized as projectile and not as document. It was thrown towards the head of those that came after him, before looking there for traces of those that had preceded him.

In sum, these are events that are extrinsic to any science and any logic ^{which} ~~that~~ lead to the composition, under the conventional form which it ends up taking in the treatises that consent still to make room for it, of a history of researches that has the pretense, be it only ritual, to retrace the logical development of a scientific idea. One should, in order to be astonished by it, not make any difference between science and history and believe for example that a biologist can write a history of the question in which they¹ are interested like they would write a memoir on the state of their work, by transposing in the confection of a history, brief or lengthy, the same criteria of

(to avoid repetition)

¹trans. note : il i.t.o., singular they i.t.t. In reading French texts, especially older, we generally abstract "il", in contexts as this one, as a faulty general gender. Here is the same passage with he, which we feel is both less natural, and less faithful also : "a biologist can write a history of the question in which he is interested like he would write"... In 1950s France parts of higher education were still not coeducational, but women had long penetrated academia, science etc. It is hard to believe that such a statement, including all of its airs of a general judgment passed on science and scientists, would be specifically meant for male scientists...

judgment that they refer to when, in their competence as a specialist, they decide over the truthfulness of a hypothesis or the fertility of a research. This hypothesis, this research, they do not see them as projects but as objects. When we judge that a scientific proposition is true we confer to it a retroactivity of validity² which subtracts it immediately from the becoming of dream, of sketches, of failures, of errors, which is to say of thoughts whose responsibility fall/are incumbent to someone. The elimination of what is false by what is true³ — that is to say verifying it — once it is accomplished, appears like the quasi mechanical effect of an impersonal necessity irresistibly manifested. That is why the importation of these norms of judgment in the domain of the historical can only there engender misunderstandings. By doing the balance/assessment of works of different researchers inside of a scientific genealogy — and one can only do it with competency as a specialist — one continues to obey to the rule of the retroactive effect of truth, since one does the historical overview of the question according to a logic of truth of the day identified with truth of always. But that is the opposite of a history and one conceives that the tendency is to reduce progressively the historical summary to nothing, since nothing ought to happen from the standpoint of where nothing fits.⁴ Without paradox, it is positivism, philosophy of history generalizing the law of succession of theories according to an irreversible movement substituting what is false with what is true, that leads to the scientific disdain for history. A library annexed to a laboratory is finally divided into two section : a museum and an atelier. There are books that one flips through as one looks at flint [hand] axes, there are others that one despoils like one uses a microtome. But where goes the frontier/limit between museum and atelier? And who traces it? And when does it move?

In fact, among the scientists that have sketched, in the last century, in a positivist or scientist spirit — which is the scientific spirit imported into history — the history of their researches have forgotten that there is no final scientific judgment and that, from a certain plane, any scientific judgment is an event. What the scientist seeks, they do not know how they will find it, otherwise it would already be there or in sight. It is maybe the illusion of the day, tomorrow refuted, that will have led to the establishment of a fact, found where it was not awaited, at the end of an inquiry, no doubt brought to light by the errors of the day before, but unconscious, on that very day, of its own becoming/future. To deny this eventuality, to admit that there is no science but in the exploitation of ideas or facts and never in their invention. However behind the words “we

²trans. note : this passage could be more easily translated so - “we confer to it retroactively a validity”... But retroactivity, if it is not a word, should be : it does ring like radioactivity and hence something that one should certainly be mindful of, careful in handling. As is the spirit and idea of this entire, long warning. It is also, simply, more faithful to the original, philosophical French. For example, Homer has been the object of brilliant prose translations — as good as it gets, written or recited when England was being flattened, and reading the epics became as important as life and death — but there is no way around experiencing those ancient texts in the cadence of sounds old as earth... Dante is a poet. And, likewise, “retroactivity of validity”, is the distinctive language of Canguilhem.

³trans. note : vrai = what is true vs. vérité = truth.

⁴trans. note : “*puisque'il ne doit rien se passer sur le plan de ce qui ne passe pas.*” Difficult passage. Passer has the ambiguity and many meanings of happening and fitting, and going, crossing and passing... In the minds of scientists who improvise themselves historians, by transposing their cultural norms to history, (e.g. covering up errors or failures), what doesn't fit didn't happen... Canguilhem's language is extremely precise leading to sometimes very long sentences that make full use of the French language's resources and infinite possibilities for word play, and if need be bending.

know", there is "we always knew". In the shadow of this negation in the perfect tense is concealed the entire history of a question. This history must be written like a history and not as a science, like an adventure and not like an unfolding. Therefore one must overturn/reverse what Bergson⁵ calls the retrograde movement of truth and put to a becoming the future truth of always. One must know to admit in the history of intelligence what is admitted in formal logic, that what is false can imply what is true.⁶ From then on one is led to not do/give logic its part, and to not show oneself indifferent to the coherence of a doctrine when one is so attentive to the coherence of successive doctrines.⁷ One rarely finds any incoherence in the thought of an author when one knows to make oneself their contemporary. Their supposed incoherence is only for the successors when they judge based on what they estimate to know better than them. That is why we cannot entirely share the judgment held by a historian of medicine as eminent as Mr. Wickersheimer : "Thomas Willis is, he too, a fervent iatrochemist ; his studies on the nervous system, his definition of the reflex owe nothing to the doctrine from which he is the adapt. Lucky consequences from which it would be easy to multiply the examples (1)." We personally do not believe in the inconsistency of Willis. It is on the contrary because he is rigorous, formally speaking, that he develops all the conclusions from fantastical premises, and that he arrives at a concept with a future, based on analogies today held for metaphors. If the historians of physiology had always been as rigorous as Willis they would not have contested to him for so long, to the profit / in favor of other authors, the paternity of the concept of reflex. Since everyone knows and says that the nervous impression is said reflected in the spinal marrow [cord] like a light ray is by a mirror, which as we saw was what Arnold, Milne-Edwards and Lapicque recalled amongst thousands, the needed conclusion was that the notion of reflex could be born — we do not say that it needed to be — inside the thought of an author for whom the animal spirits are light. Because it is not natural to introduce a law from optics in the explanation of a biological phenomena, one must be as if forced to do so by the rigor of a deduction, even if the principle, afterwards, of it reveals itself to be false.

Inversely, since Descartes had of the sensory function

(1) La médecine au XVIIe siècle, in *Les médecins célèbres*, 1947, Geneva, Lucien Mazenod, p. 84.

⁵trans. note : Bergson, in addition to being one of the best known philosophers of the first half of the 20th c., is not picked randomly : Bergson's major work, *Essai sur les données immédiates de la conscience* deals principally with consciousness and connects in many ways with the topics of La Formation. For example, take this passage from the first chapter : "The intensity of affective sensations thus would be but the consciousness that we gain of involuntary movements"...

⁶trans. note : another plausible hint to Cavailles, whose torture and killing weighed heavy in the Post-war years during which *La formation* was composed/published. (See Life and Death for more details.) Cavailles specialized among others in the history of formal logic, group theory .; author of an article on the Circle or School of Vienna. Possibly, this is also a reference to Wittgenstein.

⁷trans. note : multiplication of negations echoes directly the preceding passage on formal logic. For a more straightforward illustration see Du Bois Reymond's critique on the next page

and the motor function two radically different ideas, the notion of reflex could not find a place inside his system, however mechanist the inspiration was. Indifferent to the coherence of the author, Du Bois Reymond was also attentive to the coherence of the succession of doctrines as if the logic of the history of science were the logic of science, whose sense or direction they were so sure to possess for always. It then became logical to cross off/out Prochaska, due to the absurdity thus infertility that was supposedly that of vitalism. A bridge, sustained by La Mettrie, was established between Descartes and Du Bois Reymond, that one could walk over in two directions⁸ and at the end of which one could read Descartes with the eyes of Du Bois Reymond. But this logical rigor hides a vicious circle, a petition of principle. Prochaska is condemned and other vitalists because the vitalism has engendered nothing positive in the study of reflexes, but by foregoing so from reading them and consequently finding in their works ~~what~~ ^{what} they had put there, one accredits the idea that vitalism has never done, in biology, anything but raise obstacles or engender dreams/pondering.

In the end, the history of science can only be written with directing ideas without relation to those of science. Undoubtedly, anyone can be erudite in their hours, only patience and minutiae is needed, all qualities that scientific research develop. But history, when it takes science for object, is no more than in other tasks a simple erudition. It is a representation of significations. In that order, what the science of the day calls error has a positive right to appear at the same title as what it holds for truth. What the scientist discards the historian recuperates, without being therefore reduced to the role of dealer in second-hand wares. We should even add that it is the significant⁹ existence of the scientist themselves that justifies the enterprise of the historian. If the scientific truth is an idol of objectivity before which personal merits are annihilated, one has difficulties to understand why the mediation of so called "personal" works, even when elaborated in a team, should be needed to establish it. In those conditions, the power of excommunication from science is in the hands of no scientist. We mean to say that a scientist, if they write the history of their science or of their specialty by carrying out condemnations in the name of what is true or false at the moment, does not behave neither as a scientist, nor as a historian. As a scientist, they can indeed only confirm or critique ideas or theories without even putting themselves through the effort of knowing through whom they have come to day, and if they seek to know through whom and how they were born, their work [affaire]

⁸trans. note : again, *sense* is either the direction or the meaning (ambiguity useful once more here).

⁹trans. note : choice of *significative* is directly linked with, above, C.'s definition of history as a "representation of significations". It has also to do with the imminent introduction of latest advances in semiology (i.e. the science of signs).

which becomes that of a historian consists in understanding, which means both admitting and sympathizing.¹⁰ It is not permitted to convert intellectual exigence on the scientific ground/level/terrain into personal repulsion on the historical ground/level/terrain.

Nothing surprising hence in seeing the history of the concept composed little by little as we saw it do, since ~~there are~~ not scientific motives that lead to the sources of the history of the sciences. It convenes only to not be be dupe to the pretext of objectivity behind which hid motives necessarily foreign to any objectivity. Without any paradox, the consciousness of a situation that forbids the history of science to give/pass itself for science is still the best chance that is given¹¹, to write a history that is attentive to all, attentive to the meaning of the effort of each, a history fully significant, without ideological discrimination *a priori*, but not, of course, without appreciation of the relation between the parts and a provisory whole, between the instant and the duration¹².

These
are
non-sci.

*

* *

It is to an appreciation of this sort that the moment has arrived of submitting the results of our study.

We will conventionally call / agree to call "reflex 1800" the concept corresponding to the summary definition that we proposed.¹³ By doing the narrative of its formation, through the obstacles that have indicated, towards what history did we work ultimately? The history of scientific thought or that of pre-scientific thought? If we borrow from Mr. Bachelard the discrimination criteria / reference points of the ages of scientific thought, as he indicates them in his new law of the three states (1), we fall into great difficulty, for according to his own say, the scientific state, which extends over the XIXth century and the beginning of the XXth century, was in preparation from the end of the XVIIIth century. The task seems easier if we borrow from the same author their distinction of common experiment, non composed, made of juxtaposed observations, and scientific experiment, breaking with the first, captured in a perspective of rectified errors and of converging verifications as to their results, though independent as to their techniques (2). Experiments of Whytt and Prochaska would be common, those of Pflüger, for example, would be scientific.

When, around the years 1850-1853, Pflüger works towards establishing

(1) *La formation de l'esprit scientifique*, 1938, p. 6-7.

(2) *Ibid.*, p. 10-11.

¹⁰trans. note : as opposed to scientists whose instincts are to hide errors or failures - either in the moment or in the succession, the historian admits and seeks to understand them, bears a level of sympathy

¹¹trans. note : again more word play, *donner* and *donner pour* i.e. give vs. pretend to be.

¹²trans. note : "the instant and the duration" is a reference, here left implicit but easily attributable, to Bergson.

¹³trans. note : at the end of chapter 6.

experimentally the laws of the reflex, the reflex action isn't for him solely a hypothetical concept any longer, permitting a certain interpretation of given observations, it is to the latter a phenomenon whose legality he seeks. Pflüger knows the histologic structure of ~~the~~ ^{the} reflex ~~arc~~, whose first schema had been proposed in 1844 by Wagner, and even though this structure was far less known at the time/during this epoch than after the development/establishment by Golgi of the procedure of examination of cross sections/cuts by black coloration/staining (1873), Pflüger knows that — in any case knows better than Prochaska — through which intra-medullary relation of the ganglionic sensory neuron and of the medullary motor neuron the reflection towards the periphery of the centripetal influx is operated. But if one looks closely, here begins the movement of substitution which will lead little by little, in the vocabulary and in the thought of physiologists, the notion of reflex arc to take the place of the notion of reflex movement or action. As for this last/latter notion, as different as the evocation of experiments may be, of devices, of anatomical figures raised in our minds, depending on whether we make it contemporary of Prochaska or of Pflüger, it remains that the elements of its logical comprehension are not notably changed when we move from the reflex 1800 to the reflex 1850. There is, in the understanding of the reflex 1850 ^{than} an idea of uniformity, of rigidity of the link/liaison of reflection, more clearly marked in the reflex 1800. But, as much as it would be Pflüger who enunciated the understanding of the reflex 1850, he would uphold there an idea of teleological signification that was already found in Prochaska's thought. Such that in the eyes of one the principal heads/leaders/representatives of the concept of reflex 1850, at a well defined moment of the scientific age, the concept of the reflex 1800 is still a scientific concept.

It goes not the same for the concept of reflex as for the concept of fermentation. Of this one, we can say that Pasteur's works mark the precise break between its pre-scientific form and scientific form ; of that one, we cannot say that the first scientific works in which it appears, those of Marshall Hall and Johannes Müller, have imposed on it a revision such that only the word of it would have subsisted. The reflex 1800 did not become in 1850 a false concept, as became false, after Pasteur's works, the concepts of fermentation 1800 and of epidemic 1800. One cannot say that the reflex 1850 would be more scientific, because purged at the time of any reference to an expired / past-due-date animism¹⁴, because it is not true of Pflüger. One cannot say any more that the concept would be more scientific because it is seen in the form a reflex arc. To see a histologic cross section/cut of

¹⁴trans. note : A reader of Bachelard understands here the reference to the beginning of *La formation de l'esprit scientifique*, (i.e. about the same location previously cited by Canguilhem, p. 159), where Bachelard points out a "special" obstacle to physical sciences... being animism. He argues that this animist obstacle was "almost completely overcome" by physics in the 19th century. Canguilhem in turn - having this in mind no doubt - brings up animism, because the medical-biological sciences, contrary to their physical counterparts, had not yet purged themselves from it. [p. 21 of *The formation of the scientific spirit*, i.t.o.]

spinal marrow or [spinal] ganglion, or a neuro-muscular preparation, and see a frog summarily decapitated, is still seeing if only seeing. If one sees better the reflex of 1850, it is because one sees it not only through the eyes, but through a knowledge in which the reflex 1800 is inscribed.

This is where a truly notable difference appears between the reflex 1850 and reflex 1800. In 1800, the reflex is no doubt a "good" concept, but it is still good for nothing. It is inscribed in the books. In 1850, the concept of reflex is inscribed in the books and in the laboratory, in the form of devices of exploration and demonstration, raised for it, and which may not have been without it / were it not for it. The reflex ceases to be only concept to become percept. It exists since it brings to existence objects whose understanding it enables. Relative to the phenomenon of which it pretends to hold the explanation, it is no longer only phenomeno-logical, it is also phenomeno-technical. We find here once more a distinction familiar to the thought of Mr. Bachelard (1). It seems even better that the previous ones because it is more clear cut, more essential. The distinction between the common and the scientific is not arrested/fixed, it changes with time. The experiments of Legallois were more scientific than those of Whytt ; [put] next to experiments of Pflüger, and with greater reason next to those of Sherrington, they seem common. In the stead where the distinction between comprehending and doing, deducing and producing, is a real distinction, even if we admit that one only truly understands what one does, because if the comprehension¹⁵ gives its meaning to doing and doing its function to comprehension, it remains that one understands based on principles that are judgments and that one makes based on procedures which are gestures. And from this plane/point of view, one must maintain that if the reflex of 1850 is more scientific than the concept 1800, because it has its marked place in so many ways inside the physiologist's laboratory and because it explains a great variety of phenomena, as much instituted as given, it is not more scientific because it would be better explained, that is to say deducted. As long as we ignore, indeed, what the nervous influx is we ignore also what the reflection of the influx is and we keep the word proposed by Willis, fault of having better.

Instead of that

Such that, if a concept that is more scientific is a concept that is more phenomenotechnical, there is no reason to limit to the dimensions of laboratories of physiology the terrain

(1) *Le rationalisme appliqué*, 1949, p. 168.

out of the Bachelardian arsenal since the previous ones had no or limited results.

¹⁵trans. note : C. opts once more for the philosophical option, "le comprendre", "le faire" etc.. This preference for nominalization is such in French philosophy that it has been derided by following generations

* more visible, better expressed in various techniques, (lab, clinic, etc) devices. C uses this last criterion *

on which he makes, breaking with any verbalism, the proof of its validity. We must look up to the hospital, up to the clinic, for the trace of the reflex 1850. We observe then that the reflex of Pflüger is really inscribed in the semiology, in the techniques of research of signs whose pathognomonic value is founded on the existence of reflexes (1). When an extern on duty uses a portable electric lamp while looking for the sign of Argyll Robertson (2), he ignores, of course, who Whytt is and which magisterial description he has given of the pupillary, and he knows of Argyll Robertson what the student of mathematics knows of Chasles or of Monge¹⁶, a name, but he knows in general that he is in the course of using the presence or absence of the reflex of accommodation to light for the purpose of composing a diagnostic. And likewise who can doubt the reality of the reflex, from the day onward when, Erb or Westphal (3) having simultaneously discovered the phenomenon of muscular contraction under the effect of the percussion of the tendon, the percussion hammer or the stethoscope furnished with rubber, provisory ancestors of the future reflex hammer, are utilized systematically to provoke the famous patellar reflex? And the semiological value of the sign of Babinski (4), founded on the inversion of meaning of the plantar cutaneous reflex, achieves, at the end of the XIXth century, to give to the reflex the status of a biological fact of which one does not know anymore if its existence realizes a concept or if its concept transfers, in some sort, its existence. The reflexes exist since, in sum, the doctor treats and heals sometimes diseases/illnesses of the nervous system whose diagnostic includes, among symptoms, the effects of their troubles and of their disappearance. not

But we must go further still, by recognizing that the reflex 1850 saw its scientific validity confirmed in proportion with its vulgarization, in so far as the term of reflex has

(1) Cf. J. DÉJERINE, *Sémiologie du système nerveux*, chap. IX : "Sémiologie des réflexes", *Traité de pathologie générale*, published by Ch. BOUCHARD, t. V, Masson, 1901, p. 990-1017.

(2) *On an interesting series of eye symptoms in a case of spinal disease*, 1869. The sign of Argyll Robertson consists in the abolition of the accommodation to light with persistence of the accommodation to distance. It is a sign that orients the clinician towards the diagnostic of nervous syphilis.

3) 1° ERB, *Über Sehnenreflexe bei Gesunden und bei Rückenmarkskranken*, 1875.

2° WESTPHAL, *Über einige durch mechanischen Einwirkung auf Sehnen und Muskeln hervorgebrachte Bewegungserscheinungen*, 1875.

3° One of the first studies in French on the question is the thesis of PETITCLERC on the *Réflexes tendineux* (1880), of which CHARCOT was the rapporteur.

(4) Du phénomène des orteils et de sa valeur sémiologique, *Semaine médicale*, Paris, 1898.

¹⁶trans. note : another reference to Cavailles' area. Meant are likely the 18th-19th centuries French mathematicians Michel Chasles and Gaspard Monge. Chasles is cited in Cavailles' *Méthode axiomatique et formalisme* from 1938 [Axiomatic method and formalism]. It could also be noted at this point that this work starts with Descartes and Leibniz... (around pp. 21-26) be

exited scientific or medical vocabulary to cross over into popular vocabulary. Everyone knows today or seeks to know, in so far as their work or mode of life¹⁷ depends on it, if they have or not good reflexes. Man lives today in a form of civilization which has conferred to the rapidity and the automatism of motor reaction a double value, value of utility and of yield/efficiency/output for the machinist, prestige value for the sportsman. The reflex is thus not only any longer a scientific fact known by specialists, it is so to say a fact of public utility ~~of~~ of public notoriety. An industrial civilization cultivates the reflex reaction, whereas an agricultural civilization cultivates rather the slow or differed reaction. Thus the concept of reflex is not only guaranteed by the realizations of the physiologists and of the doctors it is a concept that the first come, among the people, claims, popularly, to be able to "realize".

But if a concept, like the one whose history we retrace, only really becomes scientific by incorporating the whole of contemporary culture, if its natural reality is guaranteed by its cultural extension, it must accept totally the verdict born from the fact of this incorporation. In so far as there is no culture but as history, the verdict of the culture is always in part submitted to revision. This leads to some conclusion that may seem ^m disappointing to all of those who think, based on different and often opposed presuppositions, that any criterion of scientific validity returns, in last analysis, to a historical criterion.

This reflex 1850 which, judging the reflex 1800, recognizes retroactively to it a value already, in big part, scientific, how is it, in turn, judged by the reflex 1900 and even by the reflex 1950? In fact the triumphant extension of the reflex 1850, in the domains of animal physiology and human neurology, has conducted it to experience/test its own limitation and in a certain sense its insufficiency, in the form, accused more and more by it, of a rigid mechanism of elementary simplicity.

Historically considered, the series of observations and studies that have led to the revision of the concept of reflex 1850, begin by a clinical surprise. The systematic research of the tendinous reflexes, and especially the patellar reflex, leads to this contesting that reflexes are neither constant nor uniform, and that their absence does not necessarily have a pathological signification. From the day when Jendrassik observes that we can make appear the absent patellar reflex, by obtaining from the examined subject that they make an effort of traction on their hands hung

¹⁷trans. note : lifestyle would be the easier, ready-made translation... but ready made doesn't always fit

by their flexed fingers, a flourishing of clinical observations drives this conclusion formulated by Déjerine : "One should be warned that outside of any pathological state, certain mechanical or physiological dispositions affect/influence the phenomenon of the tendinous reflexes... We will thus be able, in certain cases, to make these reflexes appear which were so to speak latent (1)." The outcome of these clinical observations, combined with the results of the revision of the concept of reflex in physiology and in psychology, is found in the conceptions of Goldstein, on which it would be superfluous to insist after the study of Mr. Merleau-Ponty and the French translation of *Der Aufbau des Organismus* (1934) (2).

When Sherrington discovers that, for a reflex like the scratching reflex, the limits of the field of reflexogenic excitation are variable depending on the moments, he enters a road at the end of which contemporary physiology abandons the concept of reflex supported by a linear arc which would make correspond term-for-term a punctually located stimulation and an isolable/isolatable muscular response. To which is substituted a notion of reflex from which the idea of a reaction ~~from~~ a specific organ has disappeared in favor of the idea of a type of movement already coordinated, in relation with a zone of excitations of which the global state of the organism always co-determines the effects. And that is how a French physiologist, of the school of Sherrington, L.-C. Soula, can write : "The old conception of the reflex, pedagogical routine born from the myoeptelial of the freshwater hydra and from the nervous system of the octopus, is from now on deprecated. The reflex act, as located as it may be in its reaction, is not the response of a motor element to a sensory element (*one to one* in the English language authors) ; the reflex act, even in its most simple form, is the reaction of a living being one and indivisible to an excitation of the milieu/environment (3)." by (repet.)

In the domain of the study of behavior, the progressive substitution of the concept of situation with that of stimulus and the concept of conduct with that of reaction, under the influence especially of the psychology of the form, has marked the return, beyond any of the reflexologies of mechanist style, to ethology renewed by the comparative experimentation and observation of farm animals approaching as much as possible the natural milieu/environment.

(1) *Op. cit.*, p. 996.

(2) *La structure de l'organisme*, Fr. trans. of BURCKARD and KUNTZ, Paris, Gallimard, 1951 ; see especially on the reflex, p. 57-149.

(3) *Précis de physiologie*, 2nd ed., p. 878.

The study of innate models of behavior (*innate behaviour patterns*) designates, by the place it has taken in comparative ethology, the bounds of the reflexologic explanation grappling with movements of the organism considered as a whole. The types of movements studied by K. Lorentz and N. Tinbergen, after C. O. Whitman and O. Heinroth, are characterized by the correlation of their spontaneity and of their invariability (1). When ~~these~~ internal energetic conditions are given, the movement unfolds integrally, even in an inadequate situation, under the influence of stimulation of substitution, and even after the fainting/dissipation of the initial stimulation, according to a modality of exercise that Lorentz called the idle reaction (*Leerlaufreaktion*). The motive, in the etymological sense of the term, of the movement must not be searched outside of the organism, but in it, in an accumulation of energy to liberate. The opening of the beak in the young bird/fledgling, during the moment of feeding, is one of these specific physiological movements. The study of these movements besides does not incline the authors to any philosophy and is not accompanied, in Lorentz especially, of any renaissance of the vitalism of any kind. For if these movements are spontaneous, their invariability makes them exclusive of any finalized adaptation — blow to vitalism — and if these movement are invariable they are, also, largely independent of external stimulations — blow to mechanism. At a push, by the way, it would not be absurd to interpret these phenomena by using the Cartesian schema of a motor mechanism with a central spring, unfolding all of its effects under condition of a triggering of peripheral origin. But the biological Cartesianism cannot play on all fields. If we use it here, we must renounce to it on the field of the interpretation of the reflex 1850.

Finally it is possible that the popular notoriety of the reflex is the process of changing directions, not without relation to the triple revision, in [the] clinic, in physiology, in psychology, of the reflex 1850. The development of industrial machinery towards an ever increasing automatism has made appear, as showed by G. Friedmann¹⁸ (2), the resistance that Man at work, in that they feel themselves as a whole, opposes more and more to the conjugated effort of engineers and psychotechnicians to

(1) K. LORENTZ, The comparative method in studying innate behaviour patterns, in *Symposia of the society for experimental biology*, n° IV : *Physiological Mechanisms in Animal Behaviour*, Cambridge University Press, 1950, p. 221-268.

(2) *Problèmes humains du machinisme industriel*, Paris, Gallimard, 1946.

¹⁸trans. note : one of the patrons of French sociology during that time, and almost obligatory reference at that point. It would have been permitted to expect a reference to Marx/Engels and its absence is notable in so many passages already dedicated to industrial society and its effects...

adapt, ever more tightly, the speed and uniformity of their movements, decomposed into elementary gestures, to the functioning of machines and the yield of enterprises. To the Taylorist fetishism of speed and of uniformity of simple gestures tends to substitute itself, in the actual organization of work, the taking into account of the ease of [the] behaviors of the work^{or} as an individual, that is to say as a total and singular being. It is no doubt still only a tendency, but it suffices to show that the scientific reduction of the activity of the work^{or} to a sum of mechanical reflexes would imply previously the social subordination of human work to the exclusive service of the machine. In so far as the worker refuses practically to be mechanized, he becomes proof of the theoretical error which consists in decomposing into mechanical reflexes its proper/own movements.

The expose/presentation, voluntarily rapid, of the different phases of the revision to which the reflex 1850 has been submitted, between 1900 and 1950, should not, of course, lead to the paradoxical conclusion that the reflex 1800 was more scientific than the reflex 1850 because it enclosed some reservation with regard to the purely mechanical reality of the corresponding phenomenon. However we can conclude from this that the reflex according to Prochaska had better validity than what Du Bois Reymond and his scientific epigones thought. To not appear to engage in word plays, we will not say that, far from being prescientific, the reflex 1800 contained ~~from~~ some prescience of the insufficiency, then not apparent, of the concept in the name of which it was judged. We will only say that in biology, it is possible to be a good observer, even when devoid of superior technical means that progress makes available to immediate successors, to reach some heuristic intuitions whose validity does not pertain entirely to the appreciation founded on historical criteria, intuitions relative to the meaning of biological phenomena less fluctuating than the theories composed to explain the mechanism of these same phenomena.

There can thus be following from this fact, in biology, a history of science that makes a just place to what Mr. Bachelard calls the "present/past"¹⁹, which would not be exclusively the paleontology of a certain vanished scientific spirit, which attempts to resuscitate in the original vitality the elements of what the same author calls sanctioned history (1). In writing the history of the formation, during the XVIIth and the XVIIIth centuries, of the concept of reflex, we

(1) *L'activité rationaliste de la science contemporaine*, 1951, p. 25.

¹⁹ [t.n. le passé actuel]

have wished to contribute to the constitution, as for biology, of what we would call, with Mr. Bachelard, "a recurring history, a history that clarifies though the finality of the present" (1) without all the while, no more than he himself, preaching for the return of prescientific mentalities and, in kind, to practices of medical thanatology.

We would finally not know to find better justification, for the meaning of our abridged history concerning the historical summaries of the reflex, than the few words of the physiologist V. von Weiszäcker, drawn from the introduction which he wrote for one such history brought to attention by ourselves according to its rank : "There is no road without direction, no direction without goal. It is not through deliberate words, but through an inevitable necessity that ~~the~~ the goal of this historical research is not found in history itself, but in the present. One can conceive by themselves of something only if one does not solely seek to see it, but really to see it as something, that is to recognize it. Thus we see nothing, in a succession in which we can only speak of an evolving/evolutive/evolutionary course. This presentation of the evolution of the concept of reflex has, on the contrary, the merit of forcing us to consider the question : "Evolution towards what?" The reflex is no doubt a concept which ~~had~~ had a becoming, but also a concept that we still use today. Thus the historical study bites on the scientific research in the immediate [term] (2)."

/direction

(1) *Ibid.*, p. 26.

(2) Introduction to the study of Ernst Marx, cited further above, p. 154. *Op. cit.*, p. 4.

* ~~the~~ Conclusion echoes the foreword (a defense of vitalism). ~~the~~ In the text more measu or doubt was expressed at least for Unzer (p. 113)

CONCLUSION

If one puts aside Descartes whose mechanist conception of the involuntary movement prepares, before the letter, for the concept of reflex a context of intelligibility and ulterior extensibility, more so than a necessary preliminary frame of apparition, one should ~~the~~ convene that all the authors whose responsibility is clearly and directly engaged in the formation of the explicit concept are biologists or doctors of animist or vitalist tendency, with the exception of the sole Astruc. *

The notion of reflex takes a hundred and sixty-three years, between the *De motu musculari* of Willis (1670) and the first *Memoir* of Marshall Hall (1833) to become a fact. * At the end of this period, the analogical image on which the notion rests is both familiar and forgotten, since we see J. W. Arnold recalling it (1842) in order to justify the usage of a term that M. Hall and J. Müller use as if self-evident/obvious. For fault of not having felt the need to understand the original signification of the notion, one has not always given to Willis the part that justly belongs to him. When J. M. Foster reproaches to him to have confused an image and an argument and to believe to hold a proof when he has discovered an analogy, he merely testifies to a kind of logical puritanism according to which any form of imagination would be nefarious for scientific research (1). But there is image and image. The image of a reflected light ray is barely imaginary. It is the simple vehicle, barely noticeable, that a geometrical concept borrows in order to introduce itself inside the arsenal of concepts of the physiologist. When Descartes imagines for after all he does not see them such — the nerves as bundles or pipes, the muscles like sails of ship and the living body like a clock is it more reasonable and more prudent than Willis imagining the animal spirits as light and the muscle like a fire chamber

(1) *Lectures on the History of Physiology during 16th, 17th and 18th Centuries*, 1924, p. 268 : "[Willis] looked upon an illustration as an argument, and when he discovered an analogy, thought he had found a proof."

* In ~~the~~ making ~~of~~ this observation ~~in~~ ~~an~~ ~~un~~ ~~der~~ ~~standing~~ ~~of~~ ~~the~~ ~~text~~ ~~it~~ ~~is~~ ~~probably~~ ~~inspired~~ ~~by~~ ~~Richet's~~ ~~own~~ ~~estimation~~ ~~(the~~ ~~best~~ ~~historian~~ ~~in~~ ~~the~~ ~~French~~ ~~language~~ ~~on~~ ~~the~~ ~~question~~ ~~of~~ ~~the~~ ~~previous~~ ~~century)~~ ~~where~~ ~~he~~ ~~gives~~ ~~twenty~~ ~~pages~~ ~~before~~ ~~(c.f. p. 146)~~

of a canon? If what is false can, formally speaking, imply what is true, in the name of what logic does one pretend to condemn the exercise, in the invention of scientific concepts, of an analogical imagination?

Willis had another original intuition of organic life than Descartes. It requires to be well assured of oneself to condemn the first in favor of the second. Who knows besides if these two directions of inspiration in biology are exclusive and not complementary? Descartes embarks on the study of the neuro-muscular functions through mechanics and Willis through chemistry. However the situation of physiology is not that different today. Who is closest to the scale and order of phenomena studied today by the neuro-physiologist, Descartes imagining all the structures and organic functions [based] on the model of objects and of acts that Man can do with their hands, or Willis imagining these same structures and functions [based] on the model of the operations that Man only can trigger, by letting them become/do according to a law of all or nothing? P. Valéry has written : "The substance of our body is not to our scale : the phenomena most important to us, our life, our sensitivity, our thought, are intimately linked to events smaller than the smallest of phenomena accessible to our senses, maneuverable through our acts... The nervous system, among other properties or functions, had that of linking orders of height/size very different. For example : it connects what belongs to the chemist to what belongs to the mechanic (1). * Let us hold for good, in our turn, that the physiology of the nervous system conciliates Willis and Descartes.

Let us also hold for good the greatest French philosopher ~~should be~~ based on that sole fact, the greatest of the physiologists on all points. The philosophers would benefit sometimes from a stimulating disquietude/worry[ing] that comes from seeing their authors of election/predilection through eyes other than those of the philosopher and to read the severe judgments, sometimes up to [the point of] injustice, that the doctors or the biologists, improvising themselves / turned historians, pass on Descartes as a biologist, his methodological postulates or such [or such] detail of his explanations (2).

(1) *Analecta*, 1935, Paris, Gallimard, p. 160-62.

(2) DAREMBERG is very harsh with Descartes the biologist, in his *Histoire des sciences médicales* : "What he invents [in physiology] is worth no better than what he rejects" (II, p. 702), and "neither the physiologists nor the doctors are indebted to "the great mind" of Descartes of the positive results that they have obtained" (II, p. 705). Dairemberg reports the word of Boerhaave saying that one doesn't find back Descartes in Descartes when he treats of the subjects of physiology.

E. GUYÉNOT is not more tender, in his work *Les sciences de la vie aux XVIIth and XVIIIth siècles* : "Granted, this great philosopher was neither doctor,

* Mécanicien, for which mechanic is the obvious, but the context calls for mechanist is the school of fixists.

One must also understand this point of view, even if unpleasant. As Renouvier said of the Cartesian physics that is philosophically successful (1), many a philosopher, unwilling to divide their admiration for Descartes, would gladly say of his biology that is philosophically successful. The fact is that the biologists prefer in general the biology that is biologically successful, even if it must appear to others philosophically unsuccessful/failed. What matters to the glory of Descartes that a iatrochemist should have been more successful than him in the anatomo-physiology of the involuntary movement. One won't be looking in the works of Willis for the equivalent of the *Géométrie* nor of the *Méditations métaphysiques*.

Let us admit then that the history of the biology possesses¹²⁵ not only its own logic but also its own humor. When the concept of reflex little by little acquired in the XIXth century its value of a foundation for a reflexology of mechanist and materialist style, it hid from the sight of most physiologists or psychologists its historical origins and that it had roots, in the XVIIth and XVIIIth centuries, inside biological and medical doctrines of a different inspiration than those that it was called to support and accredit. The doctrinal terrain on which was formed the concept of reflex found itself favorable, we tried to show, to the study of the functions of nervous system. One could not expect to see fall at the first blow the notion, very ancient of a center, hierarchically first, of regulation of the movements of the organism. Before conceiving the nervous system, with Sherrington, as a system of systematizations, it was first needed to conceive of it, with Unzer and Prochaska, as a system of systems. Vitalism found itself better suited than mechanism to make familiar to

nor anatomist, and he did show it" (p. 154) and "What surprises us the most, as much as we struggle to revive the ideas and the knowledge of an epoch, is that the Cartesian machine could have aroused the enthusiasm and that the principal explanations of Descartes could have become the starting point of an authentic school" (p. 158).

Ch. SINGER who speaks more favorably and, it seems, more equitably of Descartes in multiple passages of his *History of biology*, seems to us to well define the scope/reach of the biological oeuvre of Descartes : "The mechanism of Descartes stimulated many researchers. But, under its original form, the mechanist views of Descartes do not remain acceptable for long for the biologists. Over multiple generations nonetheless, some amateurs of literature with a taste for the sciences, but without personal experience of what they are, remained attached to the teaching of Descartes" (p. 386).

Here are but a few samples, extracted from books accessible to the French reader.

(1) "The physics of Descartes is a work that, philosophically, we can call successful and, in a sense, complete." *Philosophy analytique de l'histoire*, 1897, III, p. 296.

the thought of biologists the decentralization of the functions of sensory-motor coordination.

Finally we would like to draw for the usage of the history of sciences, when it seeks for this or that concept precursors or ancestors, a different conclusion. Nothing is more perilous and disappointing than wanting that, by any force of logic, contemporaries according to the civil status be also contemporaries through intellectual communication. We saw Descartes not understanding Harvey on a capital point of physiology of the circulation, Haller misunderstand/ignore the innovating ingenuity of Astruc, Du Bois Reymond become irritated at the only mention of the name of Prochaska. We saw Legallois forbid himself the systematization of his own experiments for fault of an adequate notion already formed during his time. We saw George, Jeitteles, Pflüger reproach to Marshall Hall twenty-four thousand hours of work spent on breaching doors, according to them, already open. Inversely, as to observations and experiments, Prochaska knew barely more than Willis from ^{whom} he was separated by a century and much less than Hall who was 30 at the moment of Prochaska's death. So goes scientific progress which entails as many ~~transfers~~ from one generation of researchers as affinities from one generation to another. In matters of history of science also, there is a macroscopic scale and a microscopic scale of subjects studied. When one is placed in that latter point of view, we perceive not the same links than when placed at the level of the former. In the same way that an examination with the naked eye of an oak board does not allow guessing of the Brownian motion, the same history, retraced in big lines, of the neuro-muscular physiology does not permit to guess that Willis there holds a place more important than Descartes. We can, in matters of the history of sciences, transpose the word of Pascal harsh towards Descartes and say for instance: "One must say, roughly, it was done through Descartes and Willis, because it is true. But to say which and to compose history is ridicule." Ridicule, if ^{it} is about composing history *a priori*, flaw/fault difficult to avoid, just as Pascal reproached to Descartes to compose the machine, without experiments. But neither ridicule nor false if history knows to be history, that is to say reading, in the texts, of the progressive and difficult opening of the intelligence to mechanisms, apparently illogical, of life; reading without acceleration or collision, one that is not forgetful of the incompressible duration that separates two texts where one believes to hold, through connection, the same idea. And that is why we think, contra Pascal, that ~~the~~ philosophy, that is to say the philosophy of the history of sciences, is worth one hour of pain/effort. ^{here}

delays
[décalages]

APPENDIX

SOME TEXTS OF WILLIS PRESENTED AND TRANSLATED

- A) *The maladies/illnesses of the heart : pathogenesis and therapeutics.*
 - B) *Principles of explanation of [the] muscular contraction.*
 - C) *Structure and functions of the nerve.*
 - D) *Organs and powers of the animal soul.*
-

A) MALADIES OF THE HEART :
PATHOGENESIS AND THERAPEUTICS
Extract of *Pharmaceutices Rationalis Pars Prima*
Section VI, Ch. I : *De Medicamentis Cardiacis et Alexiteriis*

... Verum enimvero cum alibi satis fuse ostendimus [...] aut ad muscolum quemvis alium pertingat... (1).

(1) *Opera Omnia*, Lyon, 1681, t. II. *Opera Omnia*, Amsterdam, 1682, p. 93-94. In that latter edition the text contains some gaps/lacks.

Of cardiac drugs and alexiterics

... Since in truth we have shown elsewhere that the support of life is far less the heart than principally and almost exclusively the blood [...] foot or any other organ...

174-75

[t.n.]

Canguilhem, who in the text made a big part to them and highlighted often the role played by translations, now makes himself a translator of Willis - further adding to his importance, and central status in the book.

As is common for editions of ancient texts the original and the translation are put side-by-side, in this case Latin on the left and French on the right.

Collection of four texts by Willis are accompanied by 12 end-notes.

These notes in turn help to, further, clarify Willis' contribution, including vis a vis - and au dessus - Descartes...

B) PRINCIPLES OF EXPLANATION
OF MUSCULAR CONTRACTION

Extract of : *De motu Musculari (Exercitatio medico-physica)*

... Hic vero imprimis repetendum erit quod superius innueram [...] has omnino a tali causa pendere... (1)

(1) *Opera Omnia*, Lyon, 1681, t. I, p. 680 sq. of the treatise *Affectionum quae dicuntur hystericae et hypochondriacae Pathologia spasmodica vindicata*.

Of muscular movement

We should first come back to what I had indicated above, namely the power, or if one wills the motor virtue of the muscle [...] it is at least permitted to presume that these contractions depend wholly on causes of this kind...

C) STRUCTURE AND FUNCTIONS OF THE NERVE

Extract of *Cerebri Anatome*

Ch. XIX : *De systemate nervoso in genere*

... Itaque ut juxta institutum nostrum systematis nervosi explicationem [...] isti velut accensi exploduntur... (1).

(1) *Opera Omnia*, Lyon, 1681, t. I, p. 336 sq.

Of the nervous system in general

To now come, in accordance with our project, to the explanation of the nervous system [...] therefrom come that they explode...

180-85

D) ORGANS AND POWERS OF THE ANIMAL SOUL

Extract of *De Anima brutorum, Pars prima physiologica*

Ch. IV : *De anima brutorum partibus sive membris*

Anima corporea Brutis perfectioribus et homini communis [...] maxime activas viventium animas conflasse...

Of the parts or of the members of the soul of the beasts

The corporeal soul, common to [the] superior/higher animals and Man [...] the souls of living beings the most subtle and the most active...

[t.n. on p. 187, in brackets, in-between sections of the text : *Willis then treats of the nature of the animal spirits and declares knowing nothing in nature to which we can compare them under all aspects. Chemical liquids (spirit of wine, turpentine) are neither elastic, nor capable of reproducing the simulacra of objects. However volatile they may be, they do not approach the subtlety of the animal spirits, evanescent as soon as life ceases.*]

Ch. VI : *De Scientia seu Cognitione brutorum*

... Quamprimum igitur brutis perfectioribus cerebrum [...] sine motuum localium habitus paulatim producantur...

Of the science or of the knowledge of beasts

As soon as in the superior/higher animals, the brain lights up [...] in other words local movements.

Ch. IX : *De sensibus speciatim, et primo de tactu*

... Species tangibilis ad hunc modum fibris nerveis [...] digito fricare aut comprimere... (1).

(1) *Opera Omnia*, Lyon, 1681, t. II, p. 29-32, p. 48 and p. 83.

Of each specie/kind of sense and first of touch

The tangible specie imprinted in this fashion onto the nervous fibers [...] where a painful sensation is excited...

[t.n. on p. 189, in brackets, before the text : *Willis starts by showing how the diversity of sensory qualities received by touch is faithfully reproduced, despite the identity of structure and of function of the nervous fibers, thanks to the diversity of movements imprinted on the animal spirits.*]

NOTES

(1) An alexiteric is, to the letter, a drug/medicine administered for preventive/preservative purposes. The word is found in the *Dictionnaire* of LITTRÉ.

(2) We present this extract, in which Willis is manifestly mistaken on the mode of action of cardiotonics, to show only how, different from Aristotle or Descartes, he insists on expelling / the expulsion of the heart from the top of the hierarchy of organs and to make it fit under the common law of muscular movement. One will compare this passage with the considerations of Aristotle in *De partibus animalium*, III, 4, 667 a 33 sq. : "The heart, as the only of the viscera and absolutely of all the body's parts, has to suffer from no serious trouble, and so with good reason : when the principle is corrupt, there is nothing that ^{could} come to the aid of the other parts on which it depends. The indication that no illness affects the heart, is that one has never observed any victim in which the heart would have been revealed to have been injured, as can be seen of all the other viscera" (see *supra*, p. 11). We will note that the Aristotelian idea, according to which the biological value of an organ that is hierarchically first leads obligatorily to its incorruptibility, is taken up by Descartes to justify the location of the soul inside the pineal gland : "... This gland, which though very small and much soft, is so well guarded in its location, that it can quasi never been subjected to any malady." *Letter to Mersenne*, July 30th 1640, A.-T., III, p. 123 ; BRIDOUX, p. 1077.

(3) We know that the *impetus*, notion which goes back to Buridan (cf. R. DUGAS, *Histoire de la mécanique*, Neuchâtel, 1950, p. 48 sq.), is that what serves to explain, until Galileo included, the movement, proportionally to the initial speed, of a mobile on which has ceased to be exercised the action of a motor. It is a term that one can't really ^{translate} but by commenting it. Let us not that Hobbes used before Willis the notion of *impetus* (and that of *conatus*) to explain the movements of the animal. can't much be (attn.)

(4) Here is definitively abandoned the idea that the nerves could provoke the muscular movement through a traction that they would exercise. The nerves have nothing in common any longer with cords/ropes/cables. It is the end of the Aristotelian confusion between nerve and tendon, confusion still latent in the galenic distinction between (sensory) soft nerves and hard nerves (motor).

(5) *Vectis, trochlea, peritrochium*, the lever, the pulley, the ^{winch} ~~which~~ or the wheel, these are simple machines whose theory DESCARTES makes in his *Explication des engins*, to Huygens, October 5th 1637, A.-T., I, p. 435 ; BRIDOUX, p. 973.

(6) Willis here makes allusion to the elastomers of certain hepatica which project the spores outside of their capsules, and to the fruits, named elaters by the botanists, which burst in their maturity, for example the wild cucumber.

(7) Until Willis the explanation of animal movement is dominated by the Aristotelian schema, "all movement is done by/through traction or by/through push". We saw that F. of Acquapendente utilizes the notion of attraction, Borelli, the notion of retraction. Descartes on the contrary uses the notion of push. Willis breaks with this schema, by transforming the alternative into a dilemma which he refuses, and by imagining the movement by/through explosion, utilizing this type of causality that BERSON called by/through "déclenchement" / triggering (*L'évolution créatrice*, 40th ed., p. 79).

(8) The flexor muscles of the thighs are the psoas and the iliac. Among the gluteal muscles [t.n. the muscles of the buttocks, the French *fessiers* is clearer], the gluteus maximus [t.n. the large one, as opposed to the middle and small ones] is a muscle extensor of the thigh (but also external rotator).

(9) We think that this fairly fuzzy/vague indication aims at the inferior insertion, on one of the subcondylar tubercles, of the great adductor muscle.

(10) We see that in matter[s] of nervous system, the anatomy of WILLIS is rigorously non Cartesian.

(11) In chap. VI of *De Anima Brutorum* (*Op. Omnia*, Lyon, 1681, II, p. 45) WILLIS describes these instruments of music (organs) and of astronomy (models of the sky).

(12) We find in this compact text, [along] with the exact description of reflex phenomena, their explanation through the notion of reflection and the distinction of types of movements founded on the anatomical distinction of the cerebral and cerebellar centers.

t.n. location of notes :

TEXT A

1 : (translated) chapter title [p. 175].

2 : end of extract [ibid.].

TEXT B

3 and 4 : "In addition/further, we have remarked that the impetuosity of the movement (3) is, by far, greater in the muscle, that is to say in its end than in its beginning or its middle. Indeed, the brain and the nerves which leave from it, composed of a tender and fragile substance, can move or attract nothing with force (4) ; whereas the muscle, manifesting a great power of contraction, seems capable of equalling the power of a lever or of a pulley." [p. 177].

5 : "In other cases, if beyond the first center of gravity other successive ones become available before the end of the movement, like in a winch (5), a same motor force normally finds itself multiplied." [ibid.]

6 and 7 : "There exist also other explosive corpuscles/particles of different sorts, enclosed in appropriate magazines, which, when they are excited to movement by/through heat or some stimulation deploy a force often unbelievable (6). From there follows that it convenes finally to research through which of these ways, it happens that the motor force in the muscles goes so much beyond the impulsion transmitted by/through the nerves from the brain, that is to say if the muscular movement is an action of pure contraction or rather elastic and in a certain way/measure explosive (7)." [p. 179]

8 and 9 : The paragraph in which these notes take place follows the one above : "On this subject, first it is manifest that the muscles have a function of attraction"... — anatomical details found, as such, in the text; and clarified in the notes. [ibid.]

TEXT D

10 : "We can conclude from this that since the spirits do not require for their expansion any apparent cavity [in the] inside [of] the nerves, they do not need any more of such a cavity inside the cerebral edifice and that it convenes to attribute to the ventricles, so called vulgarly, another function than that one... (10)." [p. 185].

11 : "... In the machines, fire, air and light are principal sources of energy that human art habitually uses for effects no less necessary as stupefying. Of which testify the furnaces of the blacksmiths, chemists, glass workers and other boilers of any kind, the glass of glasses, the instruments of music (11), the engines of war, the instruments of astronomy, as well as many other machines that we will never admire enough." [p. 187].

12 : end of extract [p. 191].

BIBLIOGRAPHY

This bibliography does not contain the totality of the works or articles cited in the course of our expose. We omit voluntarily all those that have been indicated only to authenticate an allusion or give weight to a date.

We have presented this bibliography according to a disposition which reproduces the successive moments of our study. We have indicated, at the beginning, historical works of general use, and, at the end, works of physiology, of psychology and of philosophy whose interest is not limited to the service which we have required of them. In the division that corresponds to the chapters of the present book, we have collected in A the fundamental treatises or memoirs according to a chronological order, and in B commentaries or critical studies according to an alphabetical order.

We draw the attention to that, in the course of our expose, the references to the Works [OEuvres] of Descartes have been indicated without pagination for all those that are related to texts accessible in classic or popular editions and containing divisions easily found ; for the other Cartesian texts, we refer/redirect to the Adam-Tannery edition (A.-T.), and every time it is possible to the excellent compilation published by Mr. André Bridoux in the collection of the Pléiade, 2nd edition (Bridoux).

I. — GENERAL AND SPECIALIZED HISTORY OF BIOLOGY AND OF MEDICINE

1) BIBLIOGRAPHY OF THE MEDICAL SCIENCES

GARRISON (F.H.) and MORTON (L.T.). — *A Medical Bibliography, A Check-List of texts illustrating the history of the medical sciences*, London, Grafton & Co, 1943.

2) GENERAL HISTORY

SPRENGEL (K. P. J.). — *Versuch einer pragmatischen Geschichte der Arzneikunde*, Halle, J. Gebauer, 1792-1803 (5 vol.).

DAREMBERG (Ch.). — *Histoire des sciences médicales*, 2 vol., Paris, J.-B. Baillière, 1870.

DUMESNIL (R.). — *Histoire illustrée de la Médecine*, Plon, Paris, 1935.

GUYENOT (É.). — *Les sciences de la vie aux XVIIe et XVIIIe siècles*, Paris, Albin Michel, 1941.

LEJEUNE (F.). — *Leitfaden zur Geschichte der Medizin*, Leipzig, G. Thieme, 1943.

NORDENSKIÖLD (E.). — *Geschichte der Biologie*, translated from the Swedish into German by G. SCHNEIDER, Jena, Gustav Fischer, 1926.

RADL (E.). — 1) *Geschichte der biologischen Theorien in der Neuzeit*, I, 2nd ed., Leipzig-Berlin, W. Engelmann, 1913.

— 2) *The history of biological theories*, translated from the German into English by E.J. HATFIELD, Oxford, University Press 1930.

SINGER (Ch.). — *Histoire de la biologie*, translated from the English by the Dr Gidon, Paris, Payot, 1934.

3) HISTORY OF PHYSIOLOGY

BORUTTAU (H.). — *Geschichte der Physiologie*, in *Handbuch der Geschichte der Medizin*, von Th. Puschmann, hgg. von Max Neuburger u. Julius Pagel, t. II, Jena, G. Fischer, 1903 ; p. 327-456.

FOSTER (S. M.). — *Lectures on the History of Physiology during the 16th. 17th and 18th Centuries*, Cambridge University Press, 1924, (1st ed. 1901).

ROTHSCHUH (K. E.). — *Geschichte der Physiologie*, Berlin, Springer, 1953.

4) HISTORY OF THE PHYSIOLOGY OF THE NERVOUS SYSTEM

NEUBURGER (M.). — *Die historische Entwicklung der experimentellen Gehirn und Rückenmarksphysiologie vor Flourens*, Stuttgart, F. Enke, 1897.

SOURY (J.). — *Le système nerveux central, Structure et fonctions, Histoire critique des théories et des doctrines*, 2 vol., Paris, Carré & Naud, 1899.

5) HISTORY OF THE PHYSIOLOGY OF THE MUSCLE

BASTHOLM (E.). — *The history of muscle physiology*, Copenhagen, Ejnar Munksgaard, 1950.

II. — STATE OF THE PROBLEM OF MUSCULAR MOVEMENT BEFORE DESCARTES

A) ARISTOTLE. — 1) *Aristotelis de Animalium motione et de Animalium incessu*, ed. W. Jaeger, Teubner, 1913.

— 2) *Traité de l'âme*, ed. G. Rodier, Paris, Leroux, 1900 (2 vol.).

— 3) *Historia animalium*.

— 4) *De partibus animalium*.

— 5) *De Generatione animalium*.

GALEN. — 1) *De motu musculorum*, in *Opera Omnia*, ed. Kühn, Leipzig, 1821-1833, t. IV.

— 2) *De foetuum formatione libellus*, *ibid.*, IV.

— 3) *De usu partium*, *ibid.*, III.

- 4) De placitis Hippocratis et Platonis libri novem, *ibid.*, V.
- 5) *Oeuvres choisies*, Fr. trans. by Ch. DAREMBERG, Paris, 1854 (2 vol.).
- LEONARDO DA VINCI. — *Les carnets de Léonard de Vinci*, ed. E. M. Curdy, Fr. trans. by L. SERVICEN, Paris, Gallimard, 1942 (2 vol.).
- Fabricius of ACQUAPENDENTE. — De musculus : I. De musculi fabrica, II. De musculi actione, III. De musculi utilitatibus (Vincenza, 1614), in *Opera omnia Anatomica et Physiologica*, Leyden, 1738.
- HARVEY (William). — 1) *Exercitatio anatomica de motu cordis et sanguinis in animalibus*, Frankfurt, 1628.
- 2) *Étude anatomique du mouvement du coeur et du sang chez les animaux ; historical overview and French translation by Charles LAUBRY* (Paris, Doin, 1950).
- B) ALLBUTT (S. T. C.). — The innate heat, in *Contributions to medical and biological Research, dedicated to Sir William Osler*, New York, 1919, vol. I, p. 219-225.
- BOURGEY (L.). — *Observation et expérience chez les médecins de la Collection Hippocratique*, Paris, Vrin, 1953.
- BRÉHIER (E.). — *Chrysispe*, Paris, Alcan, 1910.
- DE CORTE. — *La doctrine de l'intelligence chez Aristote*, Vrin, 1934.
- FIGARD (L.). — *Un médecin philosophe au XVI^e siècle. Étude sur la psychologie de Jean Fernel*, Paris, Alcan, 1903.
- GILSON (É.). — Descartes, Harvey et la scolastique, in *Études sur le rôle de la pensée médiévale dans la formation du système cartésien*, Paris, Vrin, 1930.
- GOMPERZ (Th.). — *Les penseurs de la Grèce*, trad. REYMOND, t. III, Lausanne-Paris, 1911.
- JAEGER (W.). — 1) *Introduction to De Animalium Motione and De Animalium Incessu*, Teubner, 1913.
- 2) Das Pneuma in Lykeion, in *Hermes*, t. XLVIII, 1913.
- 3) *Diokles von Karystos*, Berlin, 1938.
- LEBLOND (J.-M.). — *Introduction et commentaire au Livre I du traité sur Les parties des animaux*, Paris, Aubier, 1945.
- MEYER (J. B.). — *Aristoteles Thierkunde*, Berlin, 1855.
- PHILIPPSON (L. P.). — *De internarum humani corporis partium cognitione Aristotelis cum Platonis sententiis comparata*, Berlin, 1831.
- POUCHET (G.). — La biologie aristotélique, in *Revue philosophique*, 1884, II, p. 353-384 and 531-557 ; 1885, I, p. 47-63, 173-207 and 288-310.
- SCHUHL (P. M.). — Les premières étapes de la philosophie biologique, *Revue d'Histoire des Sciences*, July-September 1952, p. 197-221.
- SHERRINGTON (C. S.). — 1) Note on the history of the word tonus, in *Contributions to medical and biological Research, dedicated to Sir William Osler*, New York, 1919, I, p. 261-268.
- 2) *The Endeavour of Jean Fernel*, Cambridge University Press, 1946.
- STEIN (L.). — *Die Psychologie der Stoa*, Berlin, 1886.
- SINGER (C.) and RABIN (C.). — *A prelude to modern science (Discussion of the history, sources and circumstances of the Tabulae anatomicae sex of Vesalius)*, Cambridge University Press, 1946.

- TAYLOR (A. E.). — *A Commentary on Plato's Timaeus*, Oxford, 1928.
 VERBEKE (G.). — *L'évolution de la doctrine du pneuma, du stoïcisme à saint Augustin*, Leuven-Paris, Desclée de Brouwer, 1945.

III. — THE CARTESIAN THEORY OF INVOLUNTARY MOVEMENT

- A) DESCARTES. — 1) *Oeuvres complètes*, edition Adam & Tannery, Paris, Cerf, 1897-1910, 12 vol.
 — 2) *Oeuvres et lettres*, edition André Bridoux, collection "La Pléiade", Paris, Gallimard, 1952 (2nd edit.).
 BORELLI. — *De motu animalium I and II*, Rome, 1680-81, in Edition of Naples, 1734, augmented by the treatises of Jean BERNOULLI : *De motu musculorum* ; *De effervescentia et fermentatione*.
 B) BINET (L.). — *Médecins, biologistes et chirurgiens* (Paris, S.E.G.F.P., 1954).
 DREYFUS LE FOYER (J.). — Les conceptions médicales de Descartes, in *Revue de Métaphysique et de Morale*, January 1937, p. 237-286.
 GUEROULT (M.). — *Descartes selon l'ordre des raisons*, II, *L'âme et le corps*, Paris, Aubier, 1953.
 HERPIN (Dr A.). — *La querelle de la découverte de la circulation*, Paris, J.-B. Baillière, 1943.
 DE SAINT-GERMAIN (Dr Bertrand). — *Descartes considéré comme physiologiste et comme médecin*, Paris, V. Masson, 1869.

IV. — THE FORMATION OF THE CONCEPT OF REFLEX MOVEMENT BY THOMAS WILLIS

- A) WILLIS (Thomas). — 1) *Opera Omnia*, Lyon, 1681 (2 vol.).
 — 2) *Opera Omnia*, Amsterdam, 1682 (1 vol.).
 CROONE (W.). — *De ratione motus musculorum* (1664) ; published in t. I of the *Opera Omnia* of Willis, Lyon, 1681, p. 417-434.
 STENO (Nicolas). — *Elementorum myologiae specimen* (1667), in *Opera Philosophica*, Copenhagen, 1910, t. II.

- B) MCKIE (Douglas). — *Fire and the flamma vitalis* : Boyle, Hooke, and Mayow in *Science Medicine and History, written in honour of Charles Signer*, vol. I, Oxford University Press, 1953, p. 469-488.

V. — THE IGNEOUS SOUL

- A) GASSENDI (P.). — *Syntagmatis Philosophici Paris secundae seu Physicae sectionis teriae memberum posterius : De rebus terrenis viventibus seu de animalibus*, b. III, ch. III and XI, in *Opera Omnia*, Lyon, Anisson & Devenet, 1658.

STENO (N.). — Discours sur l'anatomie du cerveau, in *Opera Philosophica*, Copenhagen, 1910, t. II.

BERKELEY (George). — *La Siris* (1744), French translation by G. BEAULAVON and D. PARODI, Paris, A. Colin, 1920.

DE LA METTRIE (J. O.). — 1) L'homme machine (1748) in *OEuvres philosophiques*, Amsterdam, 1774 (3 vol.).

— 2) *Textes choisis*, preface and commentary by Marcelle TISSERAND (Paris, Éditions sociales, 1954).

HARTLEY (D.). — *Observations on man, his Frame, his Duty, and his Expectations*, London, 1749.

L'Encyclopédie (1751-58) : articles Ame (des bêtes), Animal, Esprits animaux, Instinct, Nerf, Musculaire, Sensibilité.

HALLER (A. VON). — *Elementa physiologiae corporis humani*, Lausanne, 1766, t. IV : *Cerebrum. Nervi. Musculi*.

B) BACHELARD (G.). — *La psychanalyse du feu*, Paris, Gallimard, 1938.

WAHL (J.). — *Tableau de la philosophie française*, Paris, Éditions de la Revue Fontaine, 1946.

VI. — DECAPITATED ANIMALS AND ORGANIC SYMPATHIES

A) Swammerdam (J.). — *Biblia naturae, sive Historia insectorum*, Leyden, t. I, 1737, t. II, 1738.

GOTTSHED. — *Dissertatio de motu musculari* (1694), in *Disputationum anatomicarum selectarum*, vol. III (*ad Lienem, Hepar, Renes, Gutem, Musculos*), collected and edited by HALLER, Göttingen, 1748.

ASTRUC (J.). — 1) *De phantasia sive imaginatione* (1723) ; 2) *An sympathia partium a certa nervorum positura in interno sensorio ?* (1736), in *Disputationum anatomicarum selectarum*, vol. IV (*ad Lienem, Hepar, Renes, Gutem, Musculos*), collected and edited by HALLER, Göttingen (1749).

L'Encyclopédie (1751-58) : article Sympathie.

WHYTT (R.). — 1) *An Essay on the Vital and other Involuntary motions of Animal*, Edinburgh, 1751.

— 2) *Observations on the Nature, Causes, and Cure of those Disorders which are commonly called Nervous, Hypochondriac, or Hysteric*, Edinburgh, 1764.

— 3) *Traité des maladies nerveuses hypocondriaques et hystériques*, Paris, Didot, 1777, preceded by an extract of the work on *Les mouvements vitaux et involontaires des animaux*.

Lecat. — *Traité de l'existence, de la nature et des propriétés du fluide des nerfs et principalement de son action dans le mouvement musculaire* ; followed by *Dissertations sur la sensibilité des meninges, des tendons, l'insensibilité du cerveau, la structure des nerfs, l'irritabilité hallerienne*, Berlin, 1765.

HALLER (A. VON). — *Elementa Physiologiae Corporis humani*, Lausanne, 1766, t. IV : *Cerebrum. Nervi. Musculi*.

BERNARD (C.). — *Le cahier rouge*, Paris, Gallimard, 1942.

- B) BACHELARD (G.). — *La terre et les rêveries du repos*, Paris, José Corti, 1948.
- FULTON (J. F.). — *Muscular Contraction and the Reflex Control of Movement*, Baltimore, Williams & Wilkins, 1926 : historical introduction, p. 3-55.
- ROSTAND (J.). — *Les origines de la biologie expérimentale et l'Abbé Spallanzani*, Paris, Fasquelle, 1951.
- ANDRÉ-THOMAS. — Le nouveau-né normal et l'anencéphale, *La Presse médicale*, 1954, n° 42, p. 885-6.

VII. — UNZER AND PROCHASKA

- A) KANT (E.). — *Träume eines Geistersehers, erläutert durch Träume der Metaphysik*, 1766.
- UNZER (J. A.) — ERSTE GRÜNDE EINER PHYSIOLOGIE DER EIGENTLICHEN THIERISCHEN NATUR THIERISCHER KÖRPER, Leipzig, Weidmanns Erben und Reich, 1771.
- PROCHASKA (G.). — 1) De functionibus systematis nervosi Commentatio, in *Adnotationum academicarum fasciculus tertius*, Prague, Wolfgang Gerle, 1784.
- 2) The same study is reproduced in t. II of *Operum minorum anatomici, physiologici et pathologici argumenti*, Vienna, Wappler & Beck, 1800.
- 3) *Lehrsätze aus der Physiologie des menschen*, Vienna, C. F. Wappler, 1797.
- BICHAT (X.). — 1) *Recherches physiologiques sur la vie et la mort* (1800), A. Delahays, 1855.
- 2) De l'influence nerveuse dans les sympathies, in *Journal de Médecine, Chirurgie. Pharmacie*, 1801, p. 472 sq.
- LEGALLOIS (C.). — *Expériences sur le principe de la vie* (1812), Paris, A. Delahays, 1855.

- A) KOYRÉ (A.). — The significance of the Newtonian synthesis, *Archives internationales d'Histoire des Sciences*, 1950, n° 11, p. 291-311.

LAIGNEL-LAVASTINE (M.). — Sources, principes, sillage et critique de l'oeuvre de Bichat, in *Bulletin de la Société française de Philosophie*, XLVI, n° 1, January-February 1952.

VIII. HISTORY OF THE HISTORIES OF THE REFLEX IN THE XIXth AND XXth CENTURIES

- HALL (Marshall). — 1) On a particular function of the Nervous System, in *Proceedings of Zoological Society*, London, 1832.
- 2) On the reflex function of the medulla oblongata and medulla spinalis, in *Philosophical Transactions of Royal Society*, London, 1833, CXXIII, p. 635-65.

MÜLLER (Johannes). — *Handbuch der Physiologie des Menschen*, I, 1833 and II, 1840, Koblenz, Hölscher.

GEORGE (J. D.). — Contribution to the history of the nervous system, *London Medical Gazette*, XXII, 1837-38, p. 40-47 and 93-96.

ARNOLD (J. W.). — *Die Lehre von der Reflex Function für Physiologen und Aerzte*, Heidelberg, 1842.

LONGET (A.). — *Traité d'anatomie et de physiologie du système nerveux*, t. I, Paris, 1842.

PFLÜGER (E.). — *Die sensorischen Functionen des Rückenmarks der Wirbeltiere nebst einer neuen Lehre über die Leitungsgesetze der Reflexionen*, Berlin, 1853.

JEITTELES (A. L.). — Wer ist der Begründer der Lehre von den Reflexbewegungen ?, in *Vierteljahrschrift für die praktische Heilkunde* (hgg. von der medizinischen Facultät in Prag), 1858, Bd IV, p. 50-72.

DU BOIS REYMOND (E.). — Gedächtnisrede auf Johannes Müller, in *Abhandlungen der Akademie der Wissenschaften*, Berlin, 1859 ; re-edited with notes in *Reden*, zweite Folge, Leipzig, 1887.

BERNARD (Claude). — *La physiologie et la pathologie du système nerveux* (lessons of the Collège de France), Paris, J.-B. Baillière, 1858.

CAYRADE (J.). — *Recherches critiques et expérimentales sur les mouvements réflexes*, Med. thesis, Paris, 1864.

VULPIAN (A.). — *Leçons sur la physiologie générale et comparée du système nerveux*, Germer Baillière, 1866.

BEAUNIS (H.). — *Nouveaux éléments de physiologie humaine*, Paris, J.-B. Baillière, 1876.

MILNE-EDWARDS (H.). — *Leçons sur la physiologie comparée de l'homme et des animaux*, t. XIII, Paris, Masson, 1878-79.

ECKHARD (C.). — Geschichte der Entwicklung der Lehre von den Reflexerscheinungen, in *Beiträge zur Anatomie und Physiologie*, Bd IX, Giessen, 1881, p. 29-192.

RICHET (Ch.). — *Physiologie des muscles et des nerfs*, Paris, Germer-Baillière, 1882.

LHERMITTE (J.). — *Les fondements biologiques de la psychologie*, Paris, Gauthier-Villars, 1925.

FEARING (F.). — *Reflex Action, a study in the history of physiological psychology*, Baltimore, Williams & Wilkins, 1930.

MARX (E.). — Die Entwicklung der Reflexlehre seit Albrecht von Haller bis in die zweite Hälfte des 19. Jahrhunderts (mit einem Geleitwort von Viktor V. Weiszäcker), in *Sitzungsbereichte der Heidelberger Akademie der Wissenschaften, Math.-naturwiss. Klasse*, Jahrgang, 1938, 10. Abhdlg, pp. 3-126.

KAYSER (Ch.). — Réflexes et comportement, in *Bulletin de la Faculté des Lettres de Strasbourg*, 1947 ; February issue, p. 89-110 and March, p. 133-148.

WICKERSHEIMER (E.). — La médecine au XVIIe siècle, in *Les médecins célèbres*, Geneva, Lucien Mazenod, 1947, p. 80-85.

HOFF (H. E.) and KELLAWAY (P.). — The early history of the reflex, in *Journal of the History of Medicine and allied Sciences*, New York, vol. VIII, 1952, n° 3, p. 211-249.

JEFFERSON (S. G.). — Marshall hall, the Grasp reflex and the diastaltic spinal cord, in *Science Medicine and History, written in honour of Charles Singer*, vol. II, Oxford University Press, 1953, p. 303-320.

IX. — PHYSIOLOGY, NEUROLOGY, PSYCHOLOGY

1) PHYSIOLOGY

BAYLISS (W. M.). — *Principles of General Physiology*, Longmans & Green, 1915.

CARDOT and LAUGIER. — Nerfs et réflexes, in *Traité de physiologie normale et pathologique*, published by G.-H. ROGER and Léon BINET, t. IX, Paris, Masson, 1933, pp. 119-211.

FULTON (J. F.). — 1) *Physiology of the nervous system*, Oxford University Press, 1938.

— 2) This work was translated into French by Ms. CHATAGNON, with a preface by the doyen Léon BINET, Paris, Vigot, 1947.

SHERRINGTON (C. S.). — *The integrative action of the nervous system*, London, A. Constable, 1906.

SOULA (L. C.). — *Précis de physiologie*, 2nd ed., Paris, Masson, 1953.

STARLING (E. H.). — *Principles of human physiology*, 2nd ed., London, Churchill, 1915 ; 8th ed. by C. LOYATT EVANS, London, Churchill, 1915 ; 8th ed. by C. LOYATT EVANS, London, Churchill, 1941.

2) NEUROLOGY

DÉJERINE (J.). — Sémiologie du système nerveux : chap. IX, Sémiologie des réflexes, in *Traité de pathologie générale*, published by Ch. BOUCHARD, t. V, Masson, 1901.

EY (H.). — Système nerveux et troubles nerveux, in *L'évolution psychiatrique*, 1947, p. 74 sq.

GOLDSTEIN (K.). — 1) *Der Aufbau des Organismus*, The Hague, Nijhoff, 1934.

— 2) *La structure de l'organisme*, Fr. trans. by BURCKARD and KUNTZ, Paris, Gallimard, 1951.

MINKOWSKI (Mieczislas). — *L'état actuel de l'étude des réflexes*, Fr. trans. by H. EY, Paris, Masson, 1927.

PETITCLERC (C.). — *Les réflexes tendineux*, Med. thesis, Paris, 1880.

3) PSYCHOLOGY

BUYTENDIJK (F. J. J.). — *Traité de psychologie animale*, Paris, P. U. F., 1952.

JANET (Pierre). — 1) *De l'angoisse à l'extase*, I, Paris, Alcan, 1926.

— 2) *Les débuts de l'intelligence*, Paris, Flammarion, 1935.

GUILLAUME (P.). — *La formation des habitudes*, Paris, Alcan, 1936.

LORENTZ (K.). — The comparative method in studying innate behaviour patterns, in *Symposia of the society for experimental biology*, n° IV : *Physiological Mechanisms in Animal Behaviour*, Cambridge University Press, 1950.

PIÉRON (H.). — *Vocabulaire de la psychologie*, Paris, P. U. F., 1951.

PRADINES (M.). — *Traité de psychologie générale*, I, Paris, P. U. F., 1943.

SPEARMAN (C.). — Les aptitudes de l'homme, trans. from the English, publication of *Travail humain*, Conservatoire national des Arts et Métiers, 1936.

X. — PHILOSOPHY OF SCIENCES AND BIOLOGICAL PHILOSOPHY

BACHELARD (G.). — 1) *La formation de l'esprit scientifique*, Paris, Vrin, 1938.

— 2) *Le rationalisme appliqué*, Paris, P. U. F., 1949.

— 3) *L'activité rationaliste de la physique contemporaine*, Paris, P. U. F., 1951.

CANGUILHEM (G.). — *La connaissance de la vie*, Paris, Hachette, 1952.

COMTE (A.). — *Cours de philosophie positive*, 43th and 44th lessons, ed. Schleicher, t. III.

DE LATIL (P.). — *La pensée artificielle, Introduction à la Cybernétique*, Paris, Gallimard, 1953.

MERLEAU-PONTY (M.). — *La structure du comportement*, Paris, P. U. F., 1942.

RUYER (R.). — 1) Le problème de l'information et la cybernétique, in *Journal de psychologie*, October-December 1952, p. 385-418.

— 2) *La Cybernétique et l'origine de l'information*, Paris, Flammarion, 1954

WIENER (N.). — *Cybernetics or control and communication in the animal and the machine*, Paris, Hermann, 1948.

Canguilhem's *La Formation* : A commentary and introduction
Camille Akmut

chapter 1	p. 2-5
chapter 2	p. 6-10
chapter 3	p. 11-13
chapter 4	p. 14-16
chapter 5	p. 17-18
chapter 6	p. 19-24
chapter 7	p. 25-39
conclusion, foreword and introduction ..	p. 40-42
bibliography	p. 43-45

Introduction

The concept of reflex underwent a series of transformations, along with other shifts in knowledge of the body of which this book gives an account.

e.g., the change from the Platonic to the Aristotelian view of the center, moving from the head to the heart, back again under Galen; or the belief in the heart's immunity to disease derived from Aristotle's metaphysics-infused physics...

As a philosopher and a doctor of medicine, Canguilhem's exceptional background - a knowledge of the humanities paired with the sciences, already highly unusual for the time period and the far advanced stage of specialization within academia and among its professional groups - is reflected in the chapters about Aristotle followed by that on Descartes, which are philosophical preludes or foundations for what would have been a more narrow, limited, conventional and expected, but scholastically acceptable account of medicine's evolution. To prepare this work C. used Ancient Greek, Latin, French, German and English sources, at least. Sources extend to roughly 1955, date of original publication, and reach up to such works as Wiener's *Cybernetics*. It should probably be mentioned that such internationalism - either through limitation or otherwise - was not obvious in French philosophers of Canguilhem's generation. The other philosopher who worked at a similar high level that comes to mind is Cavailles.

Yet, reading the first chapters, in our view the best, a history of medicine appears - much richer in addition to more interesting - in which current practices emerged after the metaphysical baggage inherited from previous epochs was abandoned... In the beginning sections of this study C. engaged in a large review of the physical, as opposed to the metaphysical, political or even logic parts of Aristotle's work, largely ignored by philosophers, being also in their majority ignorant, as they are, of science - *vice versa*. In the 4th century B.C., the debt owed by medicine to metaphysics is such that it conducts the philosopher of the history of science to use the expression "psycho-physiology" in the case of Aristotle for example¹.

The work for which we are offering an English translation is dedicated to Bachelard², a fact that is neither a detail nor a side note, who had written at length about the "unconscious" of scientists and preconceptions and prejudices of the past carrying out "silent lives" in the life of the mind - as he so vividly, and insightful, put it. A reading of *La Formation* suggests that a condition for the emergence of modern medicine and biology was the liberation from metaphysics, and those parts especially, which, unrecognized, and all the more powerful as uncovered, continued nonetheless to shape and influence the discipline over the centuries (for example the Aristotelian views' telescopic hold on Descartes' own conception of the properties of the heart). In other words are meant the continuities of metaphysics in physics... Bachelard's injection of psychological and even poetic themes in a sub-discipline reputed for austerity and seriousness, as hitherto the history of science had been stays as one of the great events in intellectual history.

But not since Celine's thesis on Semmelweis had such a book, all considered strange and beautiful, been written in that field.

Having reached the end of his doctoral thesis, now a philosopher in his own right, a master of no master and only peers, Canguilhem turned to face one last philosopher :

Why Pascal would have become a target of the young philosopher, in a stand out passage inside so far mostly erudite or prudent historical renditions and philosophical developments, is easy to understand when taking account their respective, and opposing, yes repelling, trajectories : for Pascal was the exact opposite of Canguilhem : a former prince among mathematicians, rebuked by a philosophy major turned doctor.

Canguilhem in a final sentence - an attack directed against the gentleman of Port Royal - asserted, from the perspective of the philosopher, the history of science as a

¹This terminology is inspired by or leans on Fearing's "physiological psychology".

²The second dedication is to Charles Kayser, a physiologist, professor at the Institute of Physiology in Strasbourg.

worthy activity; worthy of being put against the hour glass.

La Formation... was Canguilhem's own "formation".

A few words are in order, that end with the beginning : *La formation du concept de réflexe aux XVIIe et XVIIIe siècles*, as is the full title of this study, is a bit problematic³, being a survey from the Ancient Greeks to 20th century (first to last chapter), about Aristotle to Pavlov. It is possible that C., editors or advisors felt major achievements were located in the middle section, i.e. chapters covering the 17th and 18th centuries. * However, we feel that C.'s true contribution and primary strength resides, not e.g. in novelty of facts, most always relative, but in methodological aspects⁴, which are best appreciated as a whole; and especially strong in the beginning chapters, we believe.

As far as the title is concerned still : "La formation" appears to have been a fashionable or popular title in the 1930s, in France, i.e. when Canguilhem was a student and coming up. For example, *Études sur le rôle de la pensée médiévale dans la formation du système cartésien* (1930), to which Gilson contributed, and which C. used... One could also cite P. Guillaume's *La formation des habitudes* (1936) - with the same remark. But the most direct influence in the choice of title is no doubt Bachelard's own *La formation de l'esprit scientifique* (1938). Outside of this more local and/or timely tradition, there are of course historical precedents and - not least - Fabricius' own *De formatione ovi et pulli*!... Keeping the structure of the title intact, resulting in the translated title *The formation of the reflex concept*, means highlighting these various traditions. A more liberal translation might have been plausible, e.g. : The reflex concept, in philosophy and medicine. (From the Ancient Greeks to the XXth century.)

Canguilhem's primary competitor is F. Fearing's 1930 study *Reflex action* - which C. says had been inaccessible to him, being out of stock, until the Rockefeller Foundation intervened and procured a rare microfilm, by which point most of the research material had already been put together⁵. Fulton's 1926 *Muscular Contraction and the Reflex Control of Movement* also merits highlighting. Chapter 7, "L'histoire de l'historique...", is a historiography.

Canguilhem, who is meticulous in retracing the full genealogy of a concept now ubiquitous, we hope would not be pained by this : this book constitutes a very Bachelardian history, and as such played a key role in establishing early on the distinctively French school of the history of science - or, to be precise, *the philosophy of the history of science*, as he called it.

On the other hand, especially in times of rising nationalism, we are pushed to specify that Canguilhem - he did write in French and did use that language for scientific communication, but other than for that obvious fact - did not care particularly for nationalist ideas, indeed did not hold many of his academic compatriots in high regard : hidden at the end of the book, in the last chapter, where he reviews the state of the question in the 19th and 20th centuries, is a by-hand remark⁶ concerning "the French tendency towards the elimination of the historical". Elsewhere the existentialists are a target of C.⁷

³C. briefly addresses this problem in the foreword.

⁴Other books had been published on the subject prior, in particular Fearing's (below).

⁵Matter addressed in the foreword and in a note in the 1977 bibliography.

⁶Kayser, from Strasbourg, was an exception...

⁷In *Life and Death of Jean Cavailles*, a philosopher-mathematician whose acts in the Resistance have become something of a legendary material, we find the crushing and era defining statement : "May the philosophers of existence do better next time". (Heidegger, a member of the Nazi party, had spent the war writing letters against Jewish colleagues and sought self-promotion in the universities. Sartre, a son of the bourgeoisie, skipped the war... only to reappear with de B. at the Cafe Flore. etc. etc.. The, appreciable, and considerable, irony being of course that the existentialist philosophers had done,

* For a contrasting and correcting interpretation of this initial ~~to~~ ii impression, (and evolution in our commentary and understanding), see (Introduction (4)). However the next statement is a correct intuition (conviction) (66 v.c.).

Sartre, well known for ahistorical endless musings inspired by Heidegger, may or may not have been meant. In any case, *La Formation* was published in 1955 and thus must have been prepared or written in the immediate After War period⁸; The bloodbath of the second World War had put a dent on the nationalist and racist euphoria... Among the millions upon millions of dead was Cavailles, who was likely C.'s closest comrade, in spirit at least; a germanophile whose contributions were in the history of mathematics (a highly international discipline if there is any, due to a common language). C. himself insisted that *La Formation* was a product of the Institute of Physiology of the Faculty of Medicine of Strasbourg⁹.

To conclude this, we should be allowed to add some bitterness to so many insights and praise, in expressing the plain idea, namely that there is something troubling, and upsetting, but also liberating, about the history of medicine, especially; different in that regard from the, generally, more abstract and distant history of physics, which constituted Bachelard's domain, a nuclear bomb and more excepted of course; By this we mean the great errors integrated inside perfect, formerly metaphysical constructs, centuries long erring amid real certitude (pneuma!), and even the setbacks and temporary losses of progress, damning blindness or collective denial, punctuated by megalomania - sometimes useful, at other times vastly detrimental¹⁰;

In more recent time we must add to this list petty professional envy and careerism, up to straightforward criminality and collusion in the medical institution, ultimately large failure of the system — as in the case of the always out-of-time, lonely father of modern hygiene, whose individual results were perhaps correct, and life upright, but whose continued existence - in any case - was collectively unbearable... In the case of Semmelweis and his colleagues, might made right, as was the infamous argument used by Thrasymachus ¹² ~~against~~ *Plato's text (against Plato's master)*.

The history of the reflex concept may not be as apparently tragic, but a definite limit is certainly transgressed after Pavlov, where Canguilhem stops, and the conditioned reflex* at the latest. [*“*reflexes [which] can regularly be obtained that have no direct connection with the given stimulus*”... in Castiglioni's definition.]

And, whereas from Aristotle on the focus seemed to be on building knowledge around the body, as well as reconciling them with greater metaphysical beliefs; the Pavlovian-style experiments point to behavioral modification and control, in the context of evolving psychology and psychiatry - and lead to, and open up the properly modern era, that of the military industrial complex.

In which medicine - like the muscle - can be said to be both that which moves, and that which is moved...

indeed, *nothing* - after all the ontological meanderings and existential wandering and philosophical and literary posturing - while the historians and philosophers of science - who had never engaged in any of the *Gedankenspiele* of their colleagues, nor partaken in their particular and peculiar prose - made tremendous, and real, non hypothetical sacrifices : they turned up dead, like Cavailles, few, like Canguilhem, were able to survive the horrific opera of war. There were also sociological differences and oppositions : Sartre, a Parisian scion vs. Cavailles' military family background and Canguilhem's provincial roots or lower origins.

⁸Many of the contemporary references, notably from France and Germany, have publication dates between (late) 1930s to (mid) 1950s - in the first chapter, at least.

⁹cf. foreword.

¹⁰A recent history contains the description of the great doctor Galen - who recalls one or the other contemporary doctor - introduced as “He was big on ego-strength and seemed to assume that his was the last word on virtually everything. (...) most doctors for more than a thousand years agreed with him. Humoralism served Galen very well at the bedside, explaining disease, but he also developed a complicated physiology to explain normal bodily function, which relied on spirits (pneuma)”... [Bynum]

The setting for Canguilhem's history or rather practice of history appears now a nostalgic or idyllic one, in which - under Bachelard's influence - science confronted primarily internal struggles, and the role of the philosopher was to brilliantly untangle them, ask intelligent questions about their origins or subsistence, even bring forth poetic images and analogies, pen psycho-analytical essays...

Today's historians and philosophers - outside of the strict logicians, that is - don't have that luxury, they have little to no choice but recognize the enormous importance of outside influence. Such that, by comparison, the days where the main enemies of science were

— not Lockheed Martin, British Petroleum, a Saudi fund, Californian venture capitalism, New York banks, radical Libertarians, private space companies, billionaires, Google execs, the DoD, university administrators, college donors (a colorful crowd among which members imagine themselves great thinkers or new philosophers) —

but, *merely*, Plato's or Aristotle's confused metaphysics are almost enviable.

Lastly it appears to us, though we could be wrong, that C. may have started his inquiry with an error. All great historians start with a large error.

C.A.
June

Introduction (2)

At the bottom of *La formation...* lies the strange interest in the origins of the — supposed evident, now ubiquitous — reflex, but increasingly it becomes clear that the seemingly narrow concern leads to doing large parts of a general history of medicine; due to reflexes being connected to the muscles and key organs and parts, thought to, move or control them i.e. heart, blood, brain, nerves... and spirits!

Chapter I covered the ancient Greeks (Plato, Aristotle, Stoics, Hippocrates etc.), and their enduring influence on later major figures, among which Galen and Fabricius, in the understanding of muscular movement and the body and being as whole, in the context of a dependency, or confusion, of physics / metaphysics;

II concerns the Cartesian view, whose importance in the making of the reflex concept is recognized by both Canguilhem, who dedicates to Descartes an entire chapter, and Fearing, the latter's *Reflex Action* being headed by a portrait of that philosopher.

C. opens this new section with the question, left open (resumed after about ten pages¹), of a break happening, by attributing to Descartes “near mathematical” clarity of notions and the substitution of a mechanical approach. The question is, specifically : can the *term* and *concept* of reflex — an important distinction — be found in his work. Many authors attribute to Descartes the discovery. C. views that consensus negatively.

... And that is why the Cartesian theory is very much a mechanical theory,
but it is not a theory of the reflex. [p. 41]

Finally the chickens have come home to roost :

The second chapter is pivotal as Canguilhem confronts Fearing, “incontestably [the] most complete historian on the question”²; something that had been a long time coming.³ Among reproaches :

1) failure to establish a non-legendary history; 2) inability to fully question where, how the legend was made i.e. surrounding Descartes and the reflex; 3) lacks in critical handling of the source material.

The heavy critique begins when C. objects, in a by-line that rings like a left blow, that doing the history of a legend does not dispense from writing a factual one...

Furthermore C. creates a sociology of the two main groups that have so far joined and been involved in the field : physiologists turned historians, with weaknesses on the historical side; and philosophers with possible theoretical insights but kept back by relative ignorance of the scientific side (the last crowd he particularly associates with his French compatriots).⁴

¹cf. the paragraph beginning “We can now usefully ask ourselves the question” . . [p. 36]

²the praise, in this case, can be all the higher as C. is about to embark on a devastating critique. (In a dialectic whose logic can be briefly described as : the more accomplished the target, the higher the critic's merit; the more respected the vanquished, the more valorous the vanquisher etc. ...)

³Fearing's book has since been republished at MIT Press.

⁴Independently from Canguilhem, (the content of this book was unknown to us at the time, and certainly this passage, which we discover as we go), we had formulated a similar critique, distinguishing between computer scientists turned historians and journalists turned historians, ending with the perspective of historians or humanists who acquired an advanced knowledge of computing so as to formulate - what we had, then, called - an “external critique” that was nonetheless internally informed. — a task which computer scientists could not do (in principle as in fact).

“... too often the physiologists who have shown an interest in the history of the reflex have shown a lack of critical spirit while the philosophers have most of the time, especially in France, found in their philosophical admiration for Cartesian biology and in the insufficient biological information of their own philosophy two conjoined reasons for being no more demanding than the physiologists.”

The importance of pages 36-37 and the transition taking place there cannot be overstated, or the turning point represented by the passages of historiography in which Canguilhem develops a clear, distinctive, and arguably superior style. (In these pages, C. goes ahead with the point for point critique of Fearing). His conception and practice of the history of science, in full display here, set new standards for the area, from now on requiring in the same person abilities hitherto split into philosopher, historian and scientist, at least.

C. had a swagger - unlike the contemporary, overshadowing style of existentialists (mainly a tendency towards ahistoricism or empty pompousness, be it in the Heideggerian variant of the bucolic excess, jargon of Dasein and being-moving-through-time..., or the Parisian table waiter mind games of Sartre, for example, who knew the cafes so well because he had spent the war there...) ⁵ - that was a mix of an honest humility and relentless rigor, a precise, overbearing intelligence, occasionally bitter or sarcastic but most only in useful amounts; and that cruel character test, the experience of war conditions : when it did not shatter minds, or deaden spirits, made extraordinary. ⁶

La formation du concept de réflexe was also Canguilhem's own 'formation' : in which Canguilhem came into his own; a unique voice, respected by many, recognized individually from many.

At a meta-theoretical level — “the history of the historical”.... to continue using C.'s, possibly snarky, terminology - following pages signify the, evidently, difficult meeting of two different academic and educational cultures, and vastly different visions : Franklin Fearing and the dominant English-speaking world version of history, especially history of science and technology (as represented, e.g., at such places as the, technocratic oriented, Massachusetts Institute of Technology) on one hand; on the other the philosophically potent, theoretically high fly French philosophy and history of science of which Canguilhem, by 1950s, was the culmination and clockwork perfection.

To the terrain of the second world war, followed the artillery on the pages.

To sabotage acts, and emergency medicine, followed the subversion of history through philosophy, and the rewriting of medical history.

⁵C.'s style also differs from the baroque of the later Michel Foucault. But, in all other manners, there is a definite continuity between the history of medicine developed and found here, and the history of folly and psychiatry and of sexuality found or discovered again there..

⁶C. shared the experience of war with other historians of science and specifically of medicine, some of which we have used, evoked here (Charles Singer, Ackerknecht, etc.)

Introduction (3)

As previously announced : In the middle of chapter 2, Canguilhem creates discord in the big happy family consensus of learned gentlemen content with holding Descartes as the incontestable father of the reflex. It is so, because they said so. It is so, because others before them had said it so - you see. But not quite. There is trouble in heaven!

Here, the myth of Cartesian discovery of the reflex comes to a stop if not an end. (There is something obviously shocking, iconoclast, about the conclusions of ch. 2.)

Among others, a commentator, M., is cited whose gross, simplistic analysis creates such a big and glaring contrast once placed inside the book that even as a reader one feels second-hand embarrassment. Then, comes Fearing's turn : "adopts the opinion of Eckhard, without having the curiosity to go back" [p. 42]. Critique of Hoff and Kellaway has comical aspects also (a reading not as "manifest" as they believe)¹.

[Separately, Fulton got a similar treatment in the first note of p. 51.]

Canguilhem does, however, go back to the original document, *Treatise of Passions*, creates a context for the article invoked by the above - at once distinguished and undistinguishing - scholars, and arrives at a different conclusion; following a logic or method that corresponds to what is normally taught at the good faculties of history (i.e., the context is derived from the surrounding articles and the relevant definitions there found).

[The author does not bother just to correct Descartes' readers' failures :]

Even earlier, C. had pointed out an instance of Descartes himself being inconsistent, with respect to his own system or theories... In other words : the claim is of Descartes not being Cartesian at all times. Cf. the example of fermentation.² C. highlighted an incongruity with the mechanistic dimension of Cartesian theory in the form of an illustration chosen based on a natural process, over a mechanical one. Not very Cartesian...

Another important event happens in chapter 2 with the (first) mention of Pavlov [p. 44] and the Pavlovian reflex. Having established that "*the Cartesian theory ... is not the theory of the reflex*", (as per the key passage of p. 41 - which serves as a sort of intermediary conclusion), Canguilhem also excludes that Descartes could be somehow attributed the conditioned reflex.

Finally, more traces of the Canguilhem - Pascal relationship can be found in these pages. Pascal continues to function as a negative reference point. Canguilhem is clearly rather on the side of Descartes, even as he contests his legacy i.e. only the legendary parts, which he does not consider to be diminishing but just³. (C. even makes the effort to list all of Descartes, real, achievements after formulating his conclusion.⁴) In fact Pascal is more on the order of repellent for Canguilhem. The latter goes ahead with a mocking paraphrasing of *L'art de persuader*. [c.f. p. 46] It is also an occasion for Canguilhem to go full circle with Fearing and co. :

It would be stupid, naturally, to hold against Descartes to not have known how to make of his "reflected spirits" the sustained principle of an entire reflexology, but one can, irreverence excepted, refuse to admire the sequence of consequences that has led some historians of the neuro-muscular physiology to draw from two lonely words. [ibid.]

¹trans. note : cf. pp. 45-46

²trans. note : (on p. 34)

³p. 37 - quoted in part below.

⁴bottom of page 46.

[“sustained principle”, “the sequence of consequences”... are all, ironical, references to The Art of Persuasion.]

Canguilhem himself spoke about the need to separate reputation and truth, and ensuing “redistribution of merits and reparation of injustices” in a paragraph of *La formation* that sticks out due to its fairly unusual, out-of-character nature [p. 37].

C. concludes his argument about Descartes on page 48. He comes up with a last way to drive his point home, by means of a subtle, although at first confusing phrase. As for the word and notion of reflex and their place in Descartes' work, he says exactly “*Nous disons bien : y ont trouvé place, nous ne disons pas : y sont apparus.*” drawing a distinction between the aforementioned commentators' doing, i.e. the meanings that they have inserted, and what has actually emerged there.

A new topic or section begins from p 48, the one focused on Descartes completed, about the Italian school, Borelli etc., and elements of a comparative analysis (with the Cartesian view).

A further important step is reached in the following pages, and the discussion of words versus concepts plays a front role again : In Borelli we do not find the *motus reflexus* but its “equivalent” (i.e., the *motus retrogradus*). While in Baglivi we find the terms proper. [p. 49] C.'s ultimate concern - as expressed by the title of the book itself - however remains with the *notion* or *concept* of reflex. Discussion, and negative answer, are found p. 50.

(It also appears that with these authors, a break is happening on one more front : it seems that, finally, we are rid of the animal spirits...)

But the next big step is Willis' introduction on p. 50, who will be the subject of chapter 3.

Another milestone is reached because, with these authors, we are approaching the end of the 17th and entering the beginning of the 18th century.

Canguilhem stops chapter 2 with a conclusion or summary of the Cartesian theory, and its faults, from p. 52. “Il faut maintenant conclure...” If readers think C. had been harsh on the commentators, then things get nasty when Gilson's opinion is quoted for support. Descartes' view on the subject is deprecated, but worse : it was old before it was even young... C. brings down the hammer, and doubles down, by quoting a letter of Descartes to the Father Mersenne, in which he stated that his entire philosophy was worth nothing if what he had written on the question turned out wrong. [Feb. 1639]

may be borrowed from Guercourt

It could be noted here, as there is unlikely to be a different occasion, that the Descartes - Mersenne correspondence is a key primary material for Canguilhem; which makes sense considering that Mersenne is one of the most important, and one of the most interesting, figures from this period, in our view also.

At last, we feel warranted to prolong this introduction with some critiques :

Canguilhem holds against Fearing to not go far enough, by identifying a legend and not its origins, but a Marxist historian in turn would add that Canguilhem also doesn't go far enough by not considering the sociological origins of the origins of that mistake... In the Marxist tradition, (*The German Ideology*, at least), there is a correspondence between the world of thought and the material world. Marx / Engels used an analogy from optics, the camera, in order to communicate the reflection of class and ideas'

origins...; image which does bear relevance to the text's content.

C. identifies a chain of errors being behind the narrative of Cartesian discovery of reflex, yet, in doing so, does not consider the fact of its recurrence and regularity pointing to somewhere in the domain of sociology... Be that sociology of Marxist inspiration, Durkheimian, Weberian, composite, or else. Instead he is left with a - the choice is free - either naive or idealist, but in any case non explicit theory of error. Identifying each of the steps in a toothed wheel is not the same as explaining the workings of a mechanical computer.

The detestable sheepish mentality - to give a more direct denotation to the above sequence of consequences - is neither specific to the history of medicine nor even that of science, and should at least make plausible the possibility of its manifestation being a manifestation of sociology — or 'the social', as a philosopher like Canguilhem would probably have put carefully as well as with some distance.

A Marxist historian might consider a parallelism - a "rapprochement" Canguilhem would have said, not done - between features of the bourgeois character, on one hand, and characteristics, unfortunately, found in certain members of the academic profession; derived not least from the objective facts of their, clear, demographic composition. (e.g., the petty bourgeois business instinct for peace translated as search for consensus.)

Canguilhem's account of medicine proceeds not very differently and takes its enthralling nature and efficiency, and beauty, from the Bachelardian formula and model. In the background Bachelard is always hidden somewhere. Like Virgil is to Dante, a ghost, in the Divine Comedy. Not excluding surely adaptation, innovation. Just as, no matter how many times one reads the Comedy, Virgil and Dante at one point must part ways, for Beatrice from heaven appears, while that beloved father is assumed to return to the temple of light at the entry of hell.

The notion of "obstacle" is a certain mark of the Bachelardian origin, inspiration. [c.f. passages from pp. 48, 51...] i.e., epistemological obstacles. They can be of philosophical order - linked to a theory whose systematic nature excludes or hampers the emergence of notions, as Canguilhem tells us is the case with the reflex and Descartes. Or due to other inconsistencies. These can be of psychological and even linguistic nature, in Bachelard often linked with images, analogies, sayings favored by scientists, their language altogether. One could say that Descartes is unlike himself i.e. not very Cartesian by choosing the example of fermentation, but that Canguilhem is very Bachelardian on the other hand in making the observation.

A different, and arguably more interesting question, because unresolved for us, is : in what, significant, ways did Canguilhem's *Formation of the concept of reflex* depart strongly or starkly from the Bachelardian script and blueprint (if at all)?

Canguilhem's history gives room to the historical, philosophical and psychological, but may fall short in the sociological area.

In the chemist survives the alchemist. But in the historian survives the poet. From the point of view of a historian of science of the Bachelardian type, the transition from Greek - war - epic to Roman history was never fully completed.

And, where there is implicit, as the students of Bachelard so well know, the dreams are vivid and ancient... the mind cavernous and obscure, full of barely audible echoes, foreshadowing strange and unsuspected beasts...

Introduction (4)

By chapter two's end, going into chapter three, the meaning behind the full title of the book should be closer to the reader : the *concept* of reflex was formed in the 17th - 18th centuries. However one could argue that the, other, choice of "formation" does give room to interpretation, by pointing to a process whose finality or outcome is the end point, but not the full range or depth...

Although we look at this history with great admiration, and relative familiarity, we must also recognize the great distance that separates us from it. The idyll of the history and philosophy of science represented in *The formation of the concept of reflex in the XVIIIth and XVIIIth centuries*, at least in its first chapters, means that one does not need to worry about exterior interference,

{ e.g. Facebook AI researchers whose ethics are as ethical as the next paycheck allows ; anthropologists employed by Microsoft whose own anthropology, that is to say sociology, is that of the dollar bill ; the biotechnology firms that poach morally flexible scientists for lucrative afterlives ; computer science professors moonlighting as entrepreneurs, a practice so widespread and normalized that it is easier to count the exceptions ; foundations and philanthropies, so called, created by over-energetic trophy wives and the bourgeoisie's daughters ; sons of emerald miners with a chin complex, whose obsession with cars and rockets is likely expressive of a deep Freudian unconscious ; a defense i.e. war industry warranting '20,000 children watching over us from heaven', as per the Algerian diplomat's intervention... }

but, one understands, *mainly* the overcoming of epistemological "obstacles", internal incompatibilities of philosophical systems, faulty readings by learned gentlemen, the wrong choice of imagery. These were the days of that old, bold scholarship, whose every word was set in marble for eternity, and oh would we like to go back to them; to use Canguilhem's own formula, we would have if we only could have...

{ Granted there is no shortage of misguided intellectuals in our century : Artificial intelligence philosophers and thinkers on the authority of whom the greatest cause for concern is a future, hypothetical machine takeover, not present, actual economic inequality or ecological disaster ; or Oxford ethicists whose credibility is about that of the average dealer on Chicago or Detroit street corners. And, even "mediocre" writers like Heinlein, undergoing a renewal in interest. }

If chapter two is the height of *La formation*, chapter three is its heart :

In chapter two, Canguilhem mobilized a superior knowledge of Descartes, extending beyond main philosophical, physiological or medical texts, and, likely even more important, interpretative and methodological capabilities, generative of conclusions upsetting the historiography.

Chapter three can be said to be the center or heart of *La formation*, because, claims of Descartes being the father of the reflex dismissed, the attention turns to Willis, and finally the emergence of the concept itself; hence, justifying the complete title of the book, as already advanced.

On pages 57-58 Canguilhem begins the new chapter with — more trouble in the heavens of learned men! — by noting the great discord of opinions expressed by the commentators regarding Willis' legacy : according to some a "genius" or "prophet", and the author of "bad" theories...

Early on Canguilhem lands a notable observation and formula (on p. 49),

Descartes ... proceeds from the normal to the pathological. Willis proceeds from the pathological to the normal.

thus, announcing the title of a later, (more) famous work of his.

Willis, as a clinician starts from the point of view of illnesses' study hence "from the pathological" ...

In one aspect of Willis' work Canguilhem finds a "*particularly precise verification of the ideas of Mr. Bachelard*" (c.f. note three of p. 61). A further homage paid to the influential philosopher, additionally to the book dedication.

'The formation of the concept of reflex movement by Thomas Willis' : If the title of chapter 3 were not enough, Canguilhem makes no secret any longer of his own position by the time he writes : "*Willis ... formulate[s] the concept of reflex movement.*" (p. 62).

This conclusion is renewed, with even greater clarity, later on : In Willis the reflex is "an elaborated concept"; In Descartes, at most, "a fugitive image" or "a circumstantial word"... (p. 66). Two is not a habit, and once even less, not even under Descartes's authority.

And, finally the - clear - conclusion on page 67 :

it is Willis, and he really the first, who could and knew to form the concept of reflex movement [...] Birth act of which is found in De motu musculari (1670)

And, again p. 68 : "We are really here in the presence of a concept".

(By the way : note 1 of p. 67 is a striking formalization of methods - the ~~commutative law~~ ^{transitivity} of equality applied to historical or literary criticism.)

As for the reflex, pages 68-69 constitute a detailed analysis of why, in Willis, we find "*the thing, the word and the notion*". The original French formulation "*la chose, le mot et la notion*" may have been a source of information or inspiration for the later Foucault. (Cf. the title of the work of similar formulation.)

Passage on page 69 clearly echoes the one on page 37, about "redistribution of merits". Here Canguilhem debates again the "duties" of the historian of science. Descartes may possibly have been a more noble father of the reflex, but such considerations do not matter to us, as Willis "effectively" deserves that recognition.

It is another occasion for Canguilhem to settle differences with his main competition, i.e. Fearing where Willis goes, after already disagreeing on Descartes.

Canguilhem repeats, from page 70 onward, his negative or differential proof of the history of ideas (as already done for Descartes, pages 37 f.) :

Croone — a contemporary of Willis sufficiently close to him but with enough differences — is used to highlight what made Willis' contributions important, relative to other ideas put forth.

It is a proof "by the negative" or "by difference", because similarities / differences are brought to light in a way similar, (to use our own analogy!), to how images superimposed reveal common / disparate areas.

Canguilhem's insistence on the distinction between words and concepts, or notions, is echoed - we believe - in the present passages by the difference between "letter and spirit".

In other areas of knowledge one could imagine such a method useful. e.g., Law (If a country were to conduct early morning raids on neighborhoods, killing civilians, or during the night target camps, that are essentially ghettos, one would then think of the Nacht und Nebel methodic actions... But, a country ignored or pardoned for it, would also push one to acknowledge the differences that set such a country apart...)

In chapter 2, Canguilhem criticized the consensus formed around Descartes. In chapter 3, he criticizes the disorganization of his colleagues when it comes to Willis. (C. is aware of this problem and deflects it at the beginning of the new chapter.) And, adds fuel to fire in both.

Introduction (5)

Canguilhem's attitude towards Fearing is not just critical or negative :

In chapter 3, initial depreciation (*"we cannot subscribe in full to Fearing's judgment of Willis"*¹) are contrasted, a few pages later, by more obliging passages : *"a portion of Fearing's views regarding Willis' work we must follow"*. [beginning p. 72]

Already, about ten pages back, hidden at the bottom of a long note, C. had expressed praise for an *"excellent presentation of the works of Swammerdam"*². In a by-word of page 73 more of that high praise.

But one could also argue that the "distribution of merits" in Fearing's case is rather selective and strategic : extended and harsh on key issues, large and magnanimous on secondary ones... It is said that in deep parts of Sichuan some dishes are half pepper.

A repetition of Willis' contribution, clear as can be, occurs : *"Willis invented the word and the concept of reflex movement"* (on p. 74).

Another primary source of information in the case of Descartes — non obvious enough to be notable enough — are the "Letters to Elisabeth". By which must be meant the Princess. Again, a nice choice, since E. is one of the outstanding figures of that time, as one of few female philosophers, recalling Christina, Queen of Sweden, and her own "masculine" interests... This brings us to a long overdue, following point :

Maybe say something about the Huygens-Gorrespondence.

A fact so extensive and blinding that we feel embarrassed to barely mention it ; as if somehow inappropriate :

The history of the reflex, at least as far as this history goes, and likely many others, appears to be but a long sequence and long lines of men — explicitly not with a capital, of learned men that is. Some arguably better known than they should be, others maybe less than they deserved, etc.; warnings of overestimation based on reputation here; calls for finer or more tempered judgment there; yet still all men alike.

Considering that the universities remained largely closed to women until recently, it is doubtful that the author can be especially blamed for it. But, one must just as well recognize that Canguilhem, otherwise so resourceful in his critique and adroit in taking nothing for granted, is unable to even formulate the beginning of such a remark, after almost a hundred pages filled.

The grand, older university cities regularly emerge inside the text : e.g. Padoa, Oxford and Cambridge [pp. 57, 59, 70].

An article with the title 'Women and the invention of the reflex' would be an interesting challenge, especially for the anterior periods, handled here (i.e. pre-19th century). Who were the, clandestine, female operators of frogs?...

The comparative analysis between Willis and Descartes is neatly summed up on the penultimate page of the chapter. On this occasion, though left implicit, Canguilhem's method of the proof by difference, or negative proof, is renewed and including outcomes

¹P. 69 f..

²P. 62.

clarified. He observes "similarities and differences", which are enumerated.

Chapter 4 is a more or less seamless continuation, as it opens on a demonstration of same or similar type, but this time with Gassendi — a scientist, once more, close enough while also presenting sufficient deviation — in the function, role of the contrasting figure in the negative/difference proof. Canguilhem's aim in all this remains "grasping the originality of the contribution owed to"³ a particular individual, person; here Willis.

An argument for combining the histories of the sciences and philosophy, and its necessity, is found on page 81 : (background or context being discussions of the Willis - Berkeley relations, which lead to a more general point about the history of science) :

the history of biology crosses, once more, the history of philosophy, for the reason undoubtedly that here, as in so many other cases, biology returns to philosophy what it had gotten from it in another form.

Since we are not a neutral reader, and neither a leisurely one : this passage and others mean a lot to us as we have, in our own work, argued for similar relations existing between computer science and technology, and - case perhaps more untypical - literature especially science fiction.

The notion of 'singularity' is likely the best example, or the most ready made. (All the more as coming from a mathematician turned writer!) In addition to Vinge, Heinlein has served as inspiration for a variety of borrowed and adapted ideas. Even Pynchon has had a reception. Television and cinema provide a multitude of further sources. If we were allowed a risky but harmless formulation, we would say that Stark Trek and Star Wars created more computer scientists than Turing. But in one famous adaptation of a pioneering novel, we find a visualization of his test... As we are putting all of these ideas into words, it occurs to us that the 'deviant' Turing fathered a 'deviant' android...

These cross-overs and back-and-forth relations, while running deep and often not acknowledged, are such that at some point it becomes difficult to tell which are their directions or exact origin points.

Philosophy, being that tentacular discipline, of course here also has crossed over and left its mark : as just one example - if one thinks of the monad. That such a strange concept, from the already peculiar Leibnizian philosophy should have made its way into the field of programming languages, and the implementation of a particular language, surely makes for a case worth pondering over; the links between Leibniz and that science are otherwise extensive (the calculus, binary system, an improved mechanical computer etc.); as well as the social implication of a precursor to computer science intervening on moral questions and meddling in political affairs⁴.

Canguilhem's commentary of Berkeley unfolding on pages 82-83, due not least to a precise, methodical system of references, could be used as a model for historical-critical reading.

³P 81.

⁴as found, theoretically, in the *Theodicee*, and, in practice, in Leibniz' various political-diplomatic missions and employments.

perhaps more direct,
Chapter 4's function or reason of existence is the theory of the igneous soul is adopted by Willis, focus of the preceding chapter 3. (e.g. p. 86)

Newton is brought into the debate, pp. 83-84, as a representative of the "non Cartesian" type.

P. 85, Canguilhem engages again in a detailed analysis of language — still, never taking it for granted, or natural... — by using once more dictionaries as source. P. 38 was the first important occurrence, on the occasion he intended to show how "the term *reflex* was an adjective before becoming a substantive." Dictionaries, including medical, from the 19th c. were used in the latter case, while this time the *Encyclopédie* of the mid-1700s is referenced for support, specifically physiology entries. (He sees a juicy paradox, because these materialist philosophers in the articles turned out to be rather the vitalists, in his appreciation.)

If Canguilhem's relations with Fearing are more on the order of a cautious, cold war, give and take, Bachelard continues to receive the highest of honors. With so many imageries of fire involved, it was obvious that Bachelard's *La psychanalyse du feu*, at some point, would be cited. And, what better point than the scholarly front row seats equivalent, just before the conclusion... 6 citations, at least, no less. (pp. 86-87)

Chapter 4, it must be noted, is fairly unusual with its short length of only ten pages (compared with the usual twenty-some-over...). On further thought we are fairly certain that it was either done for Bachelard or on his suggestion. In some way it could be said that its end reveals its beginning. Last pages of this chapter - full of the master's references - especially point towards this direction. In some other way, and to use another formula, it could and should be read backwards.

At the end of this translation, or having almost reached the end, we have arrived at a further clarity :

96 The passage of the *Pensees* in which Pascal discusses the computer — which we hold to be of central importance for our discipline — and goes on to compare it to the process of thought in the animals is embedded, either wholly or in part, in the context of Descartes' philosophy, mechanism, the focus on animals, the ideas of man-machines and animal-machines, the post-Cartesian discussions and generally has much in common / to do with the background present in this book. Stahl and corresponding note two of page eighty-six ^{are} worth looking into. Also Descartes' quote from pp 51-55 and especially the, echoing, formulation: "... in which without there being no thought, movement is found"

Previously, we halted our translation on a quite poetic and even beautiful, although maybe not so intended, passage of the third chapter :

"Life in so far as it is movement ..., effort against inertia, is related ... to light ; and that is why ... we find in the laws of light an archetype of the laws of life."

This translation was done during the month of June, at a time when the above and so many other passages adopted a meaning less abstract. In that war, which saw human beings called "human beasts", while also conducted by the "most moral" forces, biological death was not enough; universities, libraries, archives wiped out; memories of a people had to be destroyed.

Introduction (6)

With Willis established as the father of the reflex contra Descartes, there is a sense that having accomplished the main part of the task by the time of chapter 3's end, Canguilhem is freer to explore in later ones, being able to consider connected topics (chapter 4 and the igneous soul) or "other problems" as he puts it just before chapter 5.

Chapter 5 it should be fast obvious to the reader is of a, quite, different nature with its vivid and graphic descriptions of animal experiments... Relative scenes of action contained in chapter five follow the theoretical hardiness of previous ones. There is also a shift from sections focused on thinkers (2 : Descartes, 3 : Willis) to a topic less focused on the individual.

Certainly the hardest portion of the work was accomplished in the first half of the book i.e. the first three or four chapters (with the fourth being some sort of annex of the third, arguably).

Canguilhem's new found freedom is expressed in a variety of way : at times he sets loose the poetic restraints, and engages in Bachelard-influenced analyses, at others he even engages in barely veiled childhood reminiscence.

Indeed this chapter remains a strong Bachelard-informed one :

"The vivisection goes back to the darkest of ages, which is to say the darkness of instincts and dreams."

The poetic and psychological or, more precisely, psychoanalytical mark of the master is present as certain as a peasant, a hunter, a drunk villager, a round bread or cheese, a snowy landscape, a myriad other details identifiable in the Old Masters' paintings...

This early eulogy and elevation of p. 91 is followed, really unsurprisingly, by an explicit reference to Bachelard's work p. 93 (*La terre...*).

Canguilhem's display of a fine and broad knowledge of the Bachelardian oeuvre may have had more practical reasons for Canguilhem : on one hand due to the nature of this text as a doctoral thesis, and - although linked with this fact - the appointment of Canguilhem in 1955 to positions previously held by Bachelard. (Authentic admiration or respect of the former for the latter is not in question or excluded, of course, by these elements of analysis of a more sociological type...)

For the recollections of childhood with probable autobiographical aspects ("anyone who grew up in the countryside", "as peasants know" etc.) see especially p. 92. In them he expresses the basic joys of experiencing raw nature with naive eyes; but the intention is not a literary one [à la Balzac] it is to explain — in the vein of Bachelard, always — why certain animals were picked for experimental purposes.

Animals without heads are a particular concern due to the, experimentally observed, presence of extant movements post-separation. They have two main variants : One, the

artificially produced decapitated animals — brainless through mutilation, put otherwise. Discussions and descriptions are hard enough to tolerate at times, but a new limit is transgressed when moving to humans; Two, the naturally born brainless, found in dissertations by doctors of the time described as “these monsters (without brains)”.

Although this should be true for the whole book, or for any history of medicine, in chapter 5 especially the doctors are increasingly reflected by their experiments, patients... Such that (if we are allowed this context-bound expression) *piece by piece* arises the considerable issue of the psychology and psychiatry, in some cases, of doctors and medical scientists. In a more risky proposition, we would say that their descriptions of the experiments or of the unusual newborn are also descriptions of themselves; In the, so called, monsters' observers — in some of the cases they are also their makers — we glimpse monstrous characteristics.

Chapter 5 as its title indicates to a degree, has a double component : decapitated animals, (pp. 89-96), and the doctrine or notion of sympathies, starting from page 97.

Introduction (7)

Sympathy, i.e. the physiological-pathological idea of a connection between organs, is a relevant side topic explored in the first half of chapter 5 because reflex movements can be considered forms of sympathies... [c.f. p. 102 : "a sympathetic movement - which is to say a reflex movement"]

In our commentary, we proposed a science fiction illustration, from the arguably greatest of all such television shows, *Star Trek*, to illustrate the stronger variant of sympathies between organisms, left unexplored here. (We could have cited more : in *Fringe*, at least one of the children used in experiments develops sympathies, in so far as their feelings, thoughts affect or influence their environment and those of nearby humans.)

If anything emerges that has not emerged already, then that Canguilhem's conception of the history of science is a profoundly comparative one. In this context, the proof by the negative or difference can be considered a specific case or implementation.

For example, in chapter 5's second half, the specific contributions *and* limitations of Robert Whytt are best accounted for when compared to other, relevant, scientists.

This manner of writing the history of science is present throughout the book :

Whytt was a fantastical observer and experimenter but faced limits; limitations whose causes and origins are varied (e.g. dependency on a system, mistaken medical suppositions...), but in the case of Whytt a lack of theoretical courage in Canguilhem's appreciation; limitations not inevitable as overcome elsewhere, by other attempts, as not present elsewhere, in others.

Hence the next chapter. Results of the Whytt - Unzer comparison : c.f. p. 110.

Chapter 6 retains a double structure — "Unzer and Prochaska", per the title — with the following outline : Unzer from p. 108 and Prochaska from p. 115 and following.

Bachelard is Canguilhem's guide in this Inferno and Purgatory of critique. In addition to background, context or reasons advanced previously, he is sufficiently distant in both age or subject matters to never be a real competition (as Virgil is not a competitor of Dante but a father figure in the original Inferno and Purgatory of Divine Comedy). On the other hand, Fearing remains the, true, constant and principal adversary of *La formation*. First lines of this chapter are, in fact, addressed to him and a reading of Unzer and Prochaska is announced that explicitly seeks to contradict the latter's, correct his errors.

It is no surprise that Canguilhem should now use Leibniz, (pp. 109-113 at least), in order to explain Unzer. The above highlighted benefits of the comparative method in history. A comparison, or parallel, with physiology's own evolution towards comparative physiology would be in order, maybe.

Lastly, Prochaska brings an end to the "animal spirits", favoring as substitute for them the "nervous force". [p. 115] *Although, the first substitution is owed to Haller (ibid.).*

*Unzer's status is uncertain in terms of the vitalist interpretation (p. 113). However Prochaska **

Introduction (8)

La formation can be said to end with chapter 6. Prochaska calls us back to Descartes, and with this the study goes full circle, thus this study's end returns us to its beginning.

Canguilhem himself writes, with only ten more pages to go : "*we are reaching the end of our historical and critical researches*" (p. 120). Confirming what we had advanced or anticipated by calling the last chapter a chapter of historiography ("l'historique ...").

A final summary of the book is given from p. 127 onward. The "summary definition" found at the very end, p. 131, is another striking use of methods and specifically of formalization; either innovated or mobilized by Canguilhem for the sake of sciences' history.

Faithful, hence, to the comparative method, and on the topic of Descartes, C. concludes or generalizes : "Prochaska studies bottom up a hierarchy of nervous centers, Descartes constructs top-down the nervous system." [p. 121]

C. rests his case against Fearing, where Unzer and Prochaska are concerned, p. 122 ("One can understand our surprise now, expressed when we said ourselves surprised to see Fearing...").

As the main part of the book nears its end, modernity too — and the advent of (electronic) computers — comes rushing forth :

A notable event happens in the ending pages with the critique of Norbert Wiener and *Cybernetics* by Canguilhem, mentions of "electronic machines" - now serving as analogy for the nervous system (replacing clocks of old), of "simulations" of behavior (Walter, Ducrocq), of a publication in French on artificial intelligence (1953's *La pensée artificielle* at Gallimard) and several others on cybernetics (1954's *La Cybernétique et l'origine de l'information* at Flammarion). [p. 122-123] References to latest happenings, trends are anything but evident considering the context of a relative microcosm of French academia, and an icing on the cake, all the more so for the epoch; on the other hand C. was anything but average (cf. our previous remarks on the internationalism or strongly international character, orientation of his scholarship).

Norbert Wiener - high priest from that certain Institute - gets a clap back when he opines to make empty talk with the entire, controversial, history of mechanism-vitalism. Canguilhem, on the contrary, argues the important or interesting questions are badly asked ones as they do not presuppose, the knowledge of, an answer. And, hence are really questions, and not answers masquerading as questions. Canguilhem calls Wiener, mockingly, "an amateur of [only] well asked questions". [p. 123] A bit later, he refers implicitly to Wiener and his crowd as "(the) cyberneticians of the day"... [p. 124]

Canguilhem's contradiction of Wiener takes on a metatheoretical value, we feel, for the whole project - a book we called strange, a book on the initially thought highly specific issue of the reflex concept. "A question never seems well asked except in the moment when it receives its solution, that is to say when it vanishes as a question."

→ The critique of Wiener has with also, and perhaps mainly, for background his attack on vitalism (as ~~merely~~ a "new mechanism"?) e. conf. p. 122

Canguilhem couldn't have said it, so we will do it for him, as good as we can : These last pages veer strongly towards the domain of - then non existent or rather non organized - computer science and informatics.

Canguilhem, without understanding it, or being able to, makes observations that in retrospective at least take on a new meaning or importance for sub-fields such as distributed systems and its concerns with fault tolerance and even up to current edge topics like chaos theories and automated fault injections. Keeping in mind the whole business of decapitated animals, we can re-read following passages for what they are : Canguilhem compares the sectioned body used in experiments on the functions of the nervous system to a computer or network with degraded functions :

This system [i.e. the nervous system] remains capable of characteristic performances after removals or degradations that no machine, especially at the electronic scale, could support, without errors ...

(p. 123)

In science fiction — but not there only any longer — answers to this problem, i.e. limitation of the mechanical, have long been the idea of the final fusion of Man and Machine. In there, some of the most advanced computers, machines, robots... are based on humans, or aspects of - formerly, uniquely - human biology.

A last side exploration begins from pp. 124-125 concerning the end of 18th c. French vitalists, i.e. Bichat and Legallois.

Canguilhem's practice of history, one its most underrated and endearing parts, entails an interest not only in successes — or questions "well asked" and answers well answered... — but in failures also, regularly.

He asks : why did the French vitalists miss the issue so badly, when they did? His interest in Bichat specifically is all the greater as the latter was interested in sympathies, a connected topic to the question of reflex.

Canguilhem called one of his methods the proof by the negative, but here one would be tempted to say that we are dealing with a demonstration by the... rear end? In any case, Canguilhem can surely be said - a compliment to a mind whose workings are captivating - to be interested in the underbelly of science, not just its glorious aspects. He looks at its bad days, not just those moments of triumph, to put it yet otherwise. And, most importantly perhaps, behind this interest lies not just a curiosity for the obscure or a twisted Schadenfreude, but an honest interest to know, to understand, to explain.

In that way, and generally, Canguilhem remains a Bachelardian. On the other hand Bachelard could be said - whereas Canguilhem kept a balance - to be *most interested* in the failures, in the gaps of knowledge, in the uncertainties, in the missed opportunities, indeed in the badly formulated questions, the poorly thought out vocabularies, the inadequate images of scientists, and so forth.

A researcher can be pardoned for ignorance, but not for distaste, Canguilhem taught us in *La formation*.

Canguilhem doesn't like Pascal very much. Now we must oppose some final resistance of our own :

That Pascal went around to aristocrats, like a Steve Jobs before his time, to acquire capital or fame; that gentlemen and royal houses became forerunners for conventions and Apple-style revelations of products; all that can be lightly mocked, if one wills, and if one knows; or merely appreciated and contextualized. Flamboyant comparisons, flashy images, and the bold formulas, are not lacking in this department; and we could go on by stating that before Andreesen there was Christina of Sweden, or that nobility sponsoring of mechanical computers was an antecedent to the modern form of venture capitalism, and that new nobility from California...

But that Pascal began asking questions, in the 17th century!, about the intelligence of computers and their relation to animal thought — questions that would have been plenty relevant for this study, had Canguilhem not ignored them (had he skipped the Pensees in preparatory school?) — these are, in any case, no small events in the history of science and ideas.

It could be argued, this being said, that the minimal conditions for the title of doctor already were fulfilled by the time of chapter 3, whatever followed almost.

However, the role of chapter 5, prolonged by 6, cannot be underestimated, since it was the experiments on decapitated animals that led to major insights — why movement without a head? — and corresponding, and needed, “decentralisation” of theories, models of explanation.

In 1950s, different from today's, the doctoral thesis especially in the French style was a grand event and spectacle. Auditoriums booked, and even spectators, sometimes ready long in advance. Words echoed in large rooms that went centuries back, tested for truth and soundness with every, ever so slight, echoing feedback. *La formation* is a product of those higher, former expectations and requirements. (This changed in 1968 with the dismantlement of the University of Paris, and the transition to mass education, enabled by student protests.) In the current cannon fodder system a thesis, at worst or on average, can be an underwhelming experience, to put it gently. *La formation*, this certainly wasn't.

Indeed..., long lingered on the mind still those early, foundational chapters about the Ancient Greeks, Galen and especially that monumental revision of Descartes. Still very present, far from forgotten, by the time of chapter 6's end. And, that slap on the fingers when it comes to our most distinguished scholars.

Those who knew, knew : with *La formation's* publication, (i.e. it being made public), something big had happened, and a great intellectual born.

Philosophy constantly conducts betting against itself. But where there is insider trading there is no market.

The existentialists would have, if they could have, but they just couldn't... A bitter, self-contradicting, and annihilating lesson of philosophy was this one, that philosophy emerged in the practice of science or, somehow, in some form, from some scientific background.

Needless to say, this statement is not equivalent to the hip-hip-hooray celebrations of science of today, or yesterday.

Going back to the text, Canguilhem ridiculed those he called "*the cyberneticians of the day*", (i.e. Wiener, his Massachusetts Institute of Technology acolytes, and beyond), because they believed themselves to be superior to Descartes, while remaining below, who defended a mechanist view, on metaphysical ground...

In his final summary of "the steps in the formation of the concept [of reflex]", (pp. 127 f.), Canguilhem formulates the idea that the transition from the Aristotelian and Galenic views — each placing a center of command, either in the heart or in the brain — to the finer study of the nervous system constitutes a decentralisation and revolution, in biology, medicine, similar to the Copernic revolution and the abandonment of anthropocentrism by "Copernic, Kepler and Galileo". In other words : a revolution in the understanding of the movement in the human body, similar to the revolution in the conception of celestial bodies...

The difficulty lied in formulating a device or principle such as for it to "not be only a system but a system of systems"...

But, Canguilhem goes further in this analogy, not kept to the convened or convenient comparison with astronomy. In the ancient models, the body revolved (agitated, he says) around the heart or the brain... : "*as was the king, in monarchic politics, to obedient subjects.*" (p. 127). The government analogy is continued on the next page at least, where the counter-model is a federal republic and "the integration of local powers" (p. 128).

It was fine when Canguilhem kept to the usual parallels drawn in science history, (where the Copernic revolution is found seemingly everywhere, in every imaginable area, in every nook and cranny we could say almost), but now the communist historian must interject a few things to this bravado ending, and crash the party a little bit.

First, that decentralisation — a topic that has become central in the information age, oh dear to our technologists — alone is no guarantee of democratization... In the current 'democracies', so -falsely- called, of the capitalist world there is no king, but there is also no choice. The subjects of this system dance in the belief of their full freedom, while the old political Ptolemaic order remains largely in place, with some light modifications albeit.

On this point, we do prefer to Canguilhem's basic and naive political analysis, the eternal lines of the Communist Manifesto, on the slaves from Ancient Greece and the worker of modern times... But then again we do not read Canguilhem for his (non existent) analysis of capitalism, no more than we consult Marx and Engels for romance and fantasy.

And yet the analogy of a decentralized governance form and the organization of the nervous system, and re-routing or re-organization in the case of animals without heads, is attractive, especially in further developments, by the author :

"An organism can be composed of parts themselves organised whose consensus depends ... on connections capable of subsisting even after their liberation with respect to a center of higher integration or control." (p. 128)

Again, we must interject that if the idea is so appealing then because Canguilhem - who was not exactly a communist, nor radical - may be less closer, than he thinks, to

describing the German government or the U.S. one for that matter, than the functioning of a terrorist cell organization, whose parts have relative autonomy from each other, and can continue functioning up to a degree with some removal of parts occurring... He may be nearer, in other words, and if one wishes to take the prolonged political parallel seriously, to describing the RAF than the BRD... In any case, there is little to no "liberation" to be found in the former, whatever infatuated ideas C. may have had of them. (If the liberation meant is that of consumerism, hedonism, and election spectacle, then we must profoundly disagree, anyway.)

"The Copernic revolution, in the physiology of movement, is the dissociation of the notions of brain and of sensory-motor center, the discovery of excentric centers, the formation of the concept of reflex." [p. 127]

Having arrived at the conclusion of this translation and commentary, there is no doubt in our mind that Canguilhem's work is promised a bright future in the now dominant context of computer science and its technologies; In his connected domain of biology and medicine, no historian, period, had his abilities.

Canguilhem's work is bound to a second life, specifically in the era of bio-technologies and the ever advancing deadline of the — hypothesized, dreamed of, written, fantasized about, calculated, accounted for, feared — future of Man and Machine, and melting or confusion of the mechanical and biological.

According to even the most apt of science fictions writers, we are only a few years away from a time when, per one famous sentence, (either poetic or horrific, viewpoint depending), people love machines, but is that age not already long here?

In computer science and technologies, one of the most ready parallels is given by computer networks, where we observe — in the applications derived, if not in the science, if indeed there is a science... — an inverse phenomenon of discourse and practices going from an original decentralized design towards a, tighter, more controlled, [and more profitable], centralization...

Bright days there will be, when hackers will be carrying copies of this book.

C.A. 06-2024

p.s. The problem of science fiction is that it is constantly at risk of being overtaken, or even to be deprecated already by the time of its publication (as Descartes' own theories were supposed to be, under the pen of one commentator). In a scene of S.F. that we imagined while translating, two soldiers, one of them at least with a medical background, would be arguing over a body. "- It's too late, the head is lost." "You fool! Did you not read Pflüger?" Whatever remained of the nervous system, and especially spinal cord, would then be packaged for transport, carefully conserved. If P. was right, the "soul" was still there, somewhere to be found. This was about the last remaining moral, but more crucially for the libertarian technical limit : In the future, where everything had become information, it was only logical that the mind would be no exception.

* Aa. , attempts to argue in favor of pre-cursors are inseparable, tightly linked to national dimensions or nationality arguments. And, later yet Descartes is presented as

Commentary a "our great philosopher" (p. 144)
(~~by~~ a French commentator)

Nothing new, for the history of science: a "priority fight" breaks out around the reflex in the 19th century involving Charles Hall, Johannes Müller and J. D. George et al..

The best known such controversy is that between Leibniz and Newton, extended by the faithful Clarke, and the invention of calculus.

In computer science we have identified a similar debate existing between Pascal and Shickard and the mechanical computer. In our analysis we emphasized nationalistic elements characteristic of these debates.

With not too great surprise, a little pleasure, we find again some of the same elements in this exchange. To Hall is attributed a "wholly [or typically] British pride" i.e. "*un orgueil tout britannique*", by Cayrade (cf. p. 134). Then, the "Czech *hoře*" ~~is~~ Prochaska and the "computer" Georges Prochaska is cited, as part of the same debate. (p. 134) ~~in at least 2 publications~~

The English "spinal marrow" is a more transparent translation of *moelle épinière*, but it may also be more time fitting or appropriate. 19th c. authors at least use it, notably Hall [p. 134]. Considering that C. employs elsewhere previous nomenclature (e.g. rachidian terminology). Is "spinal cord" anachronistic current terminology? :

1) not according to a 1950s publication on Hall (which uses it in its title) [c.f. p. 136 n. 5].

2) also noteworthy, a recent translator of Galen used spinal cord in the index, but "spinal marrow" in the text and with cord added in brackets i.e. "spinal marrow [cord]". [c.f. On the Properties of Foodstuffs, Cambridge, p. 122]

German *sensorishen* is translated as, French, *sensitives* and hence the English sensory may be a better choice than sensitive. (p. 137) Or, maybe they are equal choices.

Chapter VII feels a bit disconnected from the rest of the book. Its approach focusing on historiography ("l'historique de l'histoire"...) is a contrast to previous chapters where philosophy and re-readings or re-interpretations had a bigger part. And not least because the book is expressly about "the formation of the concept of reflex in the XVIIth and XVIIIth centuries", which ended with chapter 6, but now we are crossing over to the 19th and 20th centuries... Whereas to explain the 17th and 18th century conceptions of the reflex one needed to go back to the ancient Greeks and Descartes as otherwise the animal spirits or mechanist views would make no sense, hence the earlier chapters fulfilled a role of foundation, this one doesn't. Chapter VII appears more like a stand alone journal article.

However, in the context of a doctoral thesis, it signals a knowledge of the literature, and an advanced one at that, going beyond one's era or area.

Previously, we made several times the remark that this history did not contain "ex-

(C. calls what we call externalities, "extrinsic events" - p.f. p. 155)

ternalities", elements like pettiness and envy, as found, in the history of medicine, so prominently and tragically expressed, in the case of Semmelweis and his honorable and less honorable, distinguished and less distinguished, colleagues from Vienna. Well, now they do come out in force! - one almost wishes they didn't.

Among many, "someone asked if turtles are still alive when one makes a soup out of them", based on a complaint of -the infuriated- Marshall Hall to the Royal Society... (p. 136) The question, by the way, is not entirely irrelevant since the context is movement i.e. signs of life in decapitated i.e. cut animals... But, Hall's dignity was made an affront so big that he felt "such a question calls for no remark on my part." Bless whoever asked that question, though. (Can some varieties of French cheese be said to be "still alive"?)

An interesting, and easily overlooked, aspect of Canguilhem's practice of history were the modifications he undertook to illustrations provided.

Figures 1 to 3, extracted from Descartes' oeuvre were left mostly intact from what we can tell. However for figures 4 and 5 this is not the case.

In both the modifications were left implicit. In both cases they could be well justified; further clarity through simplification, mainly, was attempted. In addition : C. might have assumed that figures were known to - presumed expert - readers, who would, hence, be able to remember differences.

In figure 4, Croone's legends were removed and his own figure enumeration. After all C. had provided new ones.

In figure 5, in Wagner's original figure he had annotated the illustration up to v. Here, again, since C. focused on the parts up to d it was justifiable.

However it is normal practice for historians to make such changes explicit. C. might have assumed that such a book was only meant or would only be of interest to specialists. Yet, as we've tried to argue it is bound to receive a larger audience : we hope this translation into the English language, the current language of science, and our commentary creating links with computer science, (links that are suggested by the text itself), will contribute to this fate or "second life".

R. Wagner's *Handwörterbuch der Physiologie*, trans. subtitle : under consideration of physiological pathology. has four volumes in total, we believe : in any case the third one is itself split into two sections, of which the first one (*Erste Abteilung*) contains the ch. VII illustration.

In it, Wagner describes the torpedo animal, (also known as electric ray), its electric organ, in a comparative fashion, including the spinal ganglion. The passage surrounding the illustration begins :

"Vergleiche ich den Bau des elektrischen Lappens aber, wie man kurzweg machen[?] kann, des elektrischen Ganglions mit einem Spinalganglion (das ich von den peripherischen Ganglien deshalb wähle, weil wir es am besten kennen), so erscheinen folgende Verschiedenheiten : ..." (p. 397)

{followed by listing of differences. (Script is an older version of German, just as Berkeley's was for English.)

A century before the publication of Wagner's pocket dictionary of physiology, (whose title is a far stretch, exaggeration - except maybe for medical standards), Musschenbroek is connected to the torpedo in relation with the Leyden jar. C.f. chapter I, p. 22.

The torpedo has long been an object of interest for doctors and philosophers, going back to the Ancient Greeks and Romans, all the way to Plato and Socrates, Hippocrates and Aristotle. Continuing with Cicero and, later, Galen among many others.

In *Meno* Socrates was compared to a torpedo, by interlocutors who felt he resembled one and his method or way of action was similar to the fish's special effect :

*I consider that both in your appearance and in other respects you are extremely like the flat torpedo sea-fish ; for it benumbs anyone who approaches and touches it (80a)*¹

Socrates :

As for me, if the torpedo is torpid while causing others to be torpid, I am like it but not otherwise. For it is not from any sureness in myself that I cause others to doubt it is from being in more doubt than anyone else (80c)

And, in conjunction with, later :

Now, by causing him to doubt and giving him the torpedo's shock. have we done him any harm? (84b)

It could be argued that the torpedo is the most philosophical of animals. But the choice may not be the best since there may not be an equality between the torpedo's own state and those who come near or in contact with it. However this was the condition set by Socrates ("torpid while causing others to be torpid"). And yet he also states next that he carries "more doubt than anyone else"...

In Aristotle's *Historia animalium* the torpedo is also mentioned multiple times (505a, 506b, 540b...), including its shock feature (620d). "The torpedo narcotizes the creatures that it wants to catch, overpowering them by the power of shock that is resident in its body" and, in the same, "the torpedo is known to cause a numbness even in human beings."²

In Hippocrates' *Regimen* the torpedo also makes an appearance in the passage starting "As to the flesh of fish, ..." where it is said that : "The torpedo, skate, turbot and such-like are light." (XLVIII).³ In this work H. covered "human regimen in its relation to health", finding his predecessors had poorly done it (I) - which is about the introduction of any philosophy, or scholarly book.

¹Translation W. Lamb (*Plato*, Vol. IV, Loeb classical library). In R. Waterfield's translation, (*Meno and Other Dialogues*, Oxford), there are welcome notes, notably in this passage for the reference to appearance : "Socrates had flat, snub-nosed features"

²Here we, still, use Thompson's translation (*The Works of Aristotle*, Vol. IV, Oxford). This edition also contains notes such as, on the page of 620d : "The torpedo's shock was first shown to be electrical by Walsh, *Phil. Trans.* 1774." For an alternative, e.g. the Loeb classical library

³Translation W. Jones (*Hippocrates*, Vol. IV, Loeb classical library).

Galen, in turn, discussed *Regimen*. He is said to have appreciated the second book, where the torpedo's (dietary) qualities are evoked, as "worthy of Hippocrates"⁴.

In Cicero's *De natura deorum* — the same with which ended chapter 4 — the torpedo again surfaces (L).

*Let us now proceed to things more familiar to us. The care of beasts for their own preservation ... Beasts, when they receive any hurt, or fear it, have recourse to their natural arms ... the cramp-fish benumbs (XLIX-L)*⁵

As there are, we feel, parallels to be drawn with the reflex being associated with pain and "conservation", evoked in many passages, omission is especially worth highlighting.

Galen was interested in the torpedo for diet and, apparently, therapeutics also. Galen, following the Hippocratic tradition, wrote copiously on food. He mentions the torpedo in *The thinning diet* as: "The only cartilaginous seafoods which are suitable are the torpedo and the stingray" (8 Meats).⁶ In *De alimentorum facultatibus* [On the Properties of Foodstuffs], which we understand to be a later treatise, in which there are repetitions or common themes, the torpedo is also a topic (35 On cartilaginous fish).

In the latter Galen also mentions the bone marrow and spinal cord (9, 10): "The spinal marrow is of the same class as the brain, and is wrongly called marrow." Similar is found in *Mixtures* (I, 565; II, 600), including culinary qualities.

Based on the compared review of references present in a recent article on the topic⁷, and that of Canguilhem's study there is an overlap between the reflex and the interest in the torpedo in the history of science in at least the following, further authors:

- Redi and by extension Lorenzini	"Francesco Redi (1671) and later his pupil Stephano Lorenzini were the first to dissect the torpedo". Cf. Lorenzini's <i>Osservazioni intorno alle Torpedini</i> (1678);
- Borelli	<i>De motu animalium</i> (1680). "extended Lorenzini's belief that the electric organ was a special type of muscle and argued that when the torpedo was touched, the electric organ of the animal contracted at high rate!" ;
- Walsh	<i>Of the electric property of the torpedo</i> (1773) ;
- Fontana	<i>Traité sur le venin de la vipère ... et sur quelques autres poissons végétaux</i> (1781) ;
- Galvani	known for his experiments on frogs' legs' contraction in relation with the spinal cord and electricity, cited "the torpedo as a prime example" (1791) ;
- Du Bois	<i>Untersuchungen über thierische Elektrizität</i> (1849)

Here, arguably, lies somewhere a missed opportunity on the part of Canguilhem.

⁴ibid. : *Regimen* I introduction (p. xxxviii). Galen, per this source, rejected the first book as "entirely divorced from his [Hip.] way of thinking" Galen's appreciation of book II is repeated in the foreword of *On the Properties of Foodstuffs* (Cambridge).

⁵Trans. C. Yonge (*Cicero's Tusculan Disputations*, Haper's new classical library). On the nature of the gods, beginning p. 209.

⁶Trans. P. Singer (*Galen: Selected works*, Oxford).

⁷Chau Wu. 1984. "Electric Fish and the Discovery of Animal Electricity" *American Scientist* 72(6).

Commentary

To Prochaska the following quality is attributed (p. 138) : “... *the merit of Prochaska. His theories do not summarize the ideas of the epoch, they contradict them.*” But, of how many could this be said today?

Another polemic over the origin of the reflex breaks out in 1858 : this debate takes on, again, a heavy nationalist turn : involving Prochaska, from the University of Prague, and German colleagues...

Canguilhem reiterates on the occasion of this chapter of historiography his contention with making Descartes the father of the reflex based on article 36 of Treatise of passions,

“... we said that if it did indeed contain the expression of *esprits réfléchis* [t.n. reflected spirits], this appellation, unique in the works of Descartes, is utilized to explain the mechanism of a behavior which is not properly speaking a reflex.”

the issue with article 13 of the same, or rather with indiscriminating or overly eager readers of Descartes, is that it requires a distinction between “a description and a definition” to be appreciated. (p. 140)

Du Bois Reymond is the origin of the myth of Cartesian paternity of the reflex. Fearing echoes Du Bois Reymond in his -misguided- view of Descartes. (p. 141)

In Canguilhem’s appreciation, Du Bois Reymond’s defense of Descartes hides behind it a defense of (his master) Johannes Müller, and is really about “recall[ing] to order a Czech professor too little convinced of the superiority of Germanic civilization.” (p. 142) In other words — that is in our own words — we are dealing with a proxy war among intellectuals...

Chapter 7 is a chapter of historiography in so far as it is about how authors from the 19th and 20th centuries viewed the past — authors that were often themselves doctors, scientists* — and interpreted and disputed the legacies of forerunners.

[*In our own work, independently, we noted how early historians of computer science for a long time were not historians but computer scientists or technologists (followed by specialized journalists); and argued, more generally, that this tended to be true of most sciences, or neglected areas, in which members of a given field or minority group had not much alternative but to do their own history. In other words, they had no choice, and improvised themselves and became historians ‘by default’, in the absence of professional historians. Separation of scientific and humanist education were a factor, and a certain snobbery or let’s call it prudence from our colleagues... We then made references to how schools of history like social history contributed to extending the reach of history by legitimizing new approaches or bringing light to previously understudied subjects. Details aside : Canguilhem expressed an analogous intuition when he wrote, on p. 144, that philosophers were “relayed” by the physiologists...]

Chapter 7 brings additional clarity or contrasting viewpoints on a number of issues, for example the explanation of one commentator that Descartes by animal spirits designates the nervous force (Milne-Edwards, cf. p. 144). Another likewise propose to replace in Descartes "that old word" with nervous influx instead; however he makes the remark that while it is "wholly modern" it is "as obscure" (Richet, c.f. p. 147).

In this regard, errors or maliciousness notwithstanding, this chapter is useful as later authors now found themselves in the position of — in order to make their claims of priority heavy — having to explain exactly the meaning, the reach, the limitations, and ultimately the relative contributions of their predecessors.

As for the 19th century, in his review of the literature Canguilhem focuses on two histories or historical overviews of the reflex that are the best in their respective categories;

- Eckhard's *Geschichte der Entwicklung der Lehre von den Reflexerscheinungen*, 1881 : "the most complete, the best informed by far" and "the first fundamental work on the question",

- Richet's *Physiologie des muscles et des nerfs*, 1882 : as the best available in French.

In a proper historiography however - which C. understands fully and does very well - the search for "the best" isn't the aim, as "the best" -unfortunately- is not necessarily the most important or influential at any given point in time. They deserve to be highlighted nonetheless of course.

More translation notes : *sensible(s)* is best translated as sensitive, because there is the additional *sensorielle* and *sensoriaux* better fitted by sensory. (e.g., for the latter, c.f. p. 145, 147)

It is a bit of a let down when it turns out that Jules Soury had already distinguished between "the word and the thing" not only where expressly applied to the issue of the history of the reflex but in the specific context of recognizing to Willis his due honors and great place in that, same, history... (p. 148 here, p. 434 in *The Central Nervous System*) Canguilhem, admittedly adroitly, pushed this revelation back, to the back and end of the book...

Although C. attempts his best to criticize Soury, (and sometimes veers on pettiness), he essentially adopts his position on key aspects of the book, being :

- 1) chapter III's crowning of Willis;
- 2) a "well measured" judgment of Descartes, cf. chapter II, in combination and linked with a re-appreciation of Willis;
- 3) the fundamental distinction of words and things in those various contexts : enabling among others the revision of Descartes and, subsequent, better view of Willis.

The dishonesty that C. so acutely perceives in others, is it not present here? Or is

it that he was aware of Soury's proclivities and intellectual errings and side activities, next to writings on medicine and biology?

In any case we should point out that Jules Soury, among many studies in a work of big or difficult variety...¹, was also the author of a *Les fonctions du cerveau* (1891); publication whose omission by C. is contestable, and so on many fronts : due to being directly related we understand to Soury's class at the Ecole Pratique mentioned by C. in the text, and not least due to content. Sub-titled "Doctrines of the School of Strasbourg, Doctrines of the Italian School", *Brain functions* starts with a review of Friedrich Goltz and his "researches on the functions of the spinal cord". In the very first pages appear the reflex along with connected animal experiments.

In page 148 we perceive, in a reference to the philosophy of mathematics, a reference to Cavailles. Previously we alluded to parallels existing between Canguilhem's *Life and Death* and this volume, and always in the background the hypocritical role played by Sartre.² The continuity between these two disparate works is provided by, again, the distinction between words and things :

"After the Liberation, some great spirits had invented l'engagement and preached it. It was not forbidden to those who, through the example of Cavailles and those like him, already knew the thing before the name, to find the invention a bit gratuitous."³

¹e.g. *Portraits of Women. Studies in Psychology* (1875), containing 'Daughters of Louis XV'; *Jesus and the Gospels* (1878), a discussion of the life of Jesus under special consideration of psychology-psychiatry (at least in chapter 1, where Jesus' insanity traits are highlighted); and a cross section of 19th century racist/nationalist ideas, apparently...

²As only one example, to give a measure of Sartre's continued hold on French society, up to the highest ranks of its intelligentsia : the companion of Thomas Piketty appeared completely unbridled on French media - amidst a piano performance, if we remember correctly... - when claiming her total devotion to Sartre and De Beauvoir (a trace of this admiration can be found in the 2015 portrait, "Julia et Agathe Cagé, les sœurs douées", from the *Nouvel Obs*)

³*Life and Death...* being a collection of writings and talks by Canguilhem, this passage is from the 1989 France Culture intervention, i.e. near-forty years later..

* Soury's fall into oblivion stands in st contrast, today with the judgment passed on which in the 1970s received the qualification of "famous" by an author ^{-Canguilhem} always measured in their compliments ~~and~~ appreciation.

The central nervous system

Commentary

(continued from last time)

Can Soury's studies of medicine and biology be separated from the rest of his writings? But, perhaps more importantly : Did his other beliefs cross over into the monumental *The central nervous system*? Our impression was that of a great divide between them, but since it is over 2.000 pages long it is impossible for us to say with certainty.

Reading an early work like *Jesus and the Gospels*, from the 1870s¹, and a later one like *Central nervous system*, published at the end of the century, with a distance of 20 years, feels like reading works by two different authors. In our understanding, Soury has now fallen into obscurity and disrepute.

In *La Formation* Soury's work about the central nervous system received a positive reception, and one could even say more than positive considering the treatment routinely reserved by Canguilhem to others.

From Canguilhem, Soury does get a critique for the ages concerning his claim that "the notion of reflex action is as old as the physiology of the marrow and encephalon". Canguilhem's argument unfolds over two pages but the short answer is : no, it's the opposite, it was the reflex, with all of its implications and consequences, that defined physiology's age.

Previously, we made an argument for links or continuities existing between this text and Canguilhem's other text *Life and Death of Jean Cavailles*, therefore we should add more furnishing to this : the first component of this collection was a talk given by Canguilhem at the University of Strasbourg in 1967, i.e. a decade after the publication of the present volume and research undertaken there for it. Among others, Canguilhem mentions Cavailles' close links to Germany, Leibniz and Malebranche (for the latter, p. 153 here for example, for the former ch. 6)...

A notable shift, transition happens in chapter 7, pp. 148-149, when Canguilhem argues that the reflex especially in its distinction of voluntary and involuntary became an object of concern in medicine because of its importance in other, key domains of society :

"If the distinction of voluntary movement and of involuntary movement has become a problem of physiology, it is due to the importance that it draws first from its religious, moral and legal significance. Before becoming a scientific problem, it is a question concerning the experience of culpability and of responsibility."

As a side note : we believe Durkheim, on suicide, formulated remarks along likewise lines, or Foucault, in his domain i.e. about "scientific problems" that are social and

¹Especially last chapters of *Jesus...*, in which Soury increasingly starts becoming preoccupied to not say obsessed with attacking Renan and Jews, turn into hardcore literature that is difficult reconciled with works like *Brain Functions* and milestone *Central Nervous System*.

political ones "first" (to paraphrase the above text).

Canguilhem links Aristotle's natural or medical writings to better known treatises on politics and morals (best known, when not exclusively so, by most philosophers with literary inclinations) on this occasion... He draws a potent parallel between "movements" of *On the movement of animals* and "acts" of *Nicomachean Ethics* - voluntary and involuntary in both cases. (c.f. p. 149)

Original text, left silent by Canguilhem, is worth quoting since it connects directly, including in its language, with the topic not only, but the above argument about the extension of social-political concerns in science. *NE*, III, 1 begins :

*"Since virtue is to do with feelings and actions, and since voluntary feelings and actions are praised and blamed, while the involuntary ones are pardoned and occasionally even pitied, presumably anyone considering virtue must determine the limits of the voluntary and the involuntary. It will be useful as well for legislators, in connection with honours and punishments."*²

From p. 149 : Canguilhem shows himself again a follower or student of Bachelard when he conceives of the history of science as the overcoming of obstacles. According to Canguilhem, there is only or valuable scientific progress where a labor or a fight takes place (c.f. beginning of the second paragraph on that page). The "real obstacles", in science, he says, "are the ones that do not fall at once". As a reminder, one of the obstacles to physical sciences mentioned by Bachelard was the animist obstacle, as proposed in chapter 1 of *La formation de l'esprit scientifique*, called 'The notion of epistemological obstacle'... (Completely overcome by 19th c. physics, according to B.)

Lines about ideas - opposed to scientific ideas - that "continue yet to live in the mind of an eminent French Aristotelian" are straight out of the Bachelardian book, canon. i.e. similar lines about alchemists found in *The formation of the scientific mind*, now adapted by Canguilhem to fit a new topic... Meant is Ravaisson, whose critique on pp. 149-150 is comedy of a high caliber.

In chapter 7, Canguilhem gives a much greater part to sociological explanations, as could be expected maybe from the expansion to 19th and 20th centuries and the historiographical focus. On page 150 he notes that after Richet historical overviews disappear from treatises and manuals of physiology. He formulates the hypothesis, though not in terms as modern as ours, of a publish-or-perish or administrative culture already setting in at the end of the 19th century leaving little time for much historical reflection...

He forgoes judgment at this point, and his opinion is not so easily derived. It seems incompatible to regard this evolution positively as a historian. All the more so as C.

²Trans. R. Crisp (*Nicomachean Ethics*, Cambridge Texts in the History of Philosophy). Other than for apparatus, e.g. Contents, the older translation by Ross et al. is hard to recommend, especially with such good recent ones available. Book III, (like II-V), is on Moral Virtue; followed by Intellectual Virtue (VI). Trans., ed. of H. G. Apostle, professor of mathematics and philosophy, is interesting - fairly close to the above vice versa.

makes the reproach to colleagues to neglect it. But he does acknowledge history is not the physiologists' main activity and is lenient, elsewhere (less so with the philosophers, who should be held to higher standards, since, inversely, the dissection table does not await them, nor the operations, nor the anatomy classes...).

In a turn of events, C. then rejects that analysis noting how this phenomenon is not observed in other countries besides France. This however changes nothing about his opinion, sneaked into the ending parts of *La Formation*, regarding what he called "the current servitude of scientific research and teaching" in France... In the case of the first edition he would have meant the 1950s, already; in the second the 1970s.

The reasoning behind that rejection is suspect to say the least, but we are not sure how much time should be spent on a critique : First, this wide ranging judgment is based on two authors... not exactly historical heavy-lifting. Then, there are the logical parts : What if France, at that time, was under specific budget cuts or a government different from what was happening in the US or UK during that same time period? As for the 1950s, France had just emerged from a bloody war, occupied, while the US had a high post-war growth, strong economy, dominance of the dollar and the Marshall Plan and seemingly unlimited war and research funds*. Details?

(*The very same which essentially permitted the creation of an entire new discipline, which flourished in the United States, i.e. computer science and related technologies, funded not least by DARPA, the DoD etc..)

C. himself received Rockefeller support and thus would know about the largesse of that country during those years; and France's comparative poverty. (The same Rockefeller foundation that funded Cavaillès already³.)

For all the great prowess in the history of science conducted after Bachelard's model, there is something that prevents Canguilhem from real sociological reasoning. Maybe it is the remnants of his philosophical training, so useful there, and so detrimental now here. C.'s critique of Soury applies : all the elements are provided, just not the solution, or in the right order...

Another evolution for which Canguilhem provides all the elements, but whose whole he does not perceive clearly - or leaves unsaid at least - is that at the turn of the 19th and 20th centuries psychology and psychiatry become ever more important and grab more and more land away from medicine, or other areas of medicine⁴, in the study of the reflex, and elsewhere. Signs of it are Soury, Griesinger, Lhermitte, among others.

About half-way through chapter VII, the line of the 20th century is crossed from p. 150.

A small detail perhaps, but it is a nice touch that Canguilhem put himself through the work of systematically providing references to Descartes according to two different editions, right up to the end (i.e. Adam-Tannery and Bridoux). But even more : when

³Life and Death, p. 1

⁴(other areas of medicine : if one considers the former to be a part of medicine, and sciences..)

other commentators cite D., he goes through the effort of sourcing quotes in the above, if our memory carries us this far. 5

In terms of historical methods, in history and philosophy, there is much to learn for a student in *La formation*. One could not be faulted for assigning it as required reading. Surely, entire battalions and successive generations of undergraduates should now be fed with Kuhn. To the teaching of the history of science Kuhn is what *The catcher in the rye* is to literature class (no one can particularly identify with it).

Critique of Lhermitte is brutal (pp. 151-152 especially). Second hand recital, lack of exactitude, probably does not know the original directly; one good intuition (p. 153).

In the 20th century, among the best publications on the history of the reflex are :
- Fearing's monograph *Reflex action* (1930) and Hoff-Kellaway's *The early history of the reflex* (1952) article.
- Charles Kayser's *Réflexes et comportement* (1947), in French. Kayser is the equivalent of Richet in that century, "by far the best"; and now dedication should make sense.

Another, subtle, change is brought by this last chapter : the United States wholly or largely absent from the history of the reflex, and by extension medicine, emerges more in the 19th, 20th centuries covered by chapter 7. Primarily in the form of commentators, rather than contributing doctors or philosophers i.e. actors of that history in a strict sense.

One could venture to formulate the hypothesis that the U.S. had produced such good historians on the question, at that point, because they had been such good observers, of a history in which they had little to no part. [Fact unusual enough in the modern period, for this expansionist, once dominating country.]

However the ultimate point of chapter 7, and to some extent the whole book, may be that historians of the reflex made the reflex as much as its doctors...

s. e.g. page 45 goes in this direction.
critique of Hoff and Kellaway on

Commentary

As the historiography proper ended on page 154, from the next page — a transition signaled by separation marks — begins a section of a different nature. The historiography is followed by a more general essay on the writing of history, and specifically how to write the history of science. (This lesson draws somewhat on the preceding history of histories...).

This shift, towards generalization, and philosophy, and philosophy of history precisely, is easily identifiable by the disappearance of notes just as the increasingly literary veering on the poetic tone. It opens with a warning :

The following warning should be read by today's dominating scientists, being those of the information sciences, due to their apparent opinion that a competency in an area like computer science confers automatically - and inexplicably if not magically - a mastery of disciplines as varied as philosophy, history, sociology, political science, law... and fields as foreign as foreign policy, politics, morals, society, government, the legal system... the list is endless :

Following extract is from the ending pages of *La formation* and concerns specifically history and biology but can easily be generalized to apply to any combination :

"One should, in order to be astonished by it, not make any difference between science and history and believe for example that a biologist can write a history of the question in which they are interested like they would write a memoir on the state of their work, by transposing in the confection of a history, brief or lengthy, the same criteria of judgment that they refer to when, in their competence as a specialist, they decide over the truthfulness of a hypothesis or the fertility of a research." (p. 155)

(As an anecdote, we still remember unpleasantly reading the 200 pages long C.V. of a certain computer scientist and can only hope they will never arrive at the - equally inane - idea of writing history or much anything outside of their domain... [Keep to the algorithms! Stay in your lane!, one can only wish sincerely and politely.]

The entirety of the argument would be worth quoting in full. Canguilhem goes on about "the importation of norms of judgment" by scientists keen to erase errors and failures, so obviously fatal in the domain of history. This passage ends with lines on "the scientific disdain for history". Qualities associated especially with the "positivist or scientist spirit". He argues that positivism and scientism are what the scientific spirit imports into history, the making or writing of history. (pp. 155-156)

For those familiar with Bachelard, the expression "l'esprit scientifique" irremediably references, reports, returns, echoes back to that philosopher. And there will be no surprise, hence, to see him cited - explicitly, this time - a few pages down. It can't be said enough : overall these are once more some very Bachelardian pages. Why is it that scientists cannot properly write history? Where do their errors come from? (Cf. the entire previous analysis.) In other words, which is to say Bachelard's words, in

Bachelardian terms : What is the obstacle?

These may be the questions, but the answer is : "This history must be written like a history and not as a science". (p. 157) This answer does not preclude in our eyes that history itself is not a science, merely that it is neither a biology, nor a physics, nor a medicine - and certainly should not be conducted as if it were so.

A principal problem being that history is written by these authors "as if the logic of the history of science were the logic of science" (p. 158). In particular this is expressed when a commentator considers the internal coherence of a given author less important than "the coherence of the succession of doctrines", or prioritizes the latter over the former... Du Bois Reymond was a sinner in this area, and the victim was Descartes. (ibid.)

It seems to be the case that many of these authors ignored the coherence of the authors they studied because they were too concerned with either creating bridges or links between these famous ancestors and themselves, or between them and living authors in their favor (e.g. former masters).

All of which lead to develop the stark affirmation : "In the end, the history of science can only be written with directing ideas that have no relation with those of science." (p. 158)

On the whole the entire conclusion of chapter 7, from pp. 155 to 158, is a strong rejection that scientists could just pick up a pen in their leisurely hours and start writing history properly, with principles unchanged, based on the common sense reasoning or reckoning that, after all, "only patience and minutiae is needed" ("all qualities that scientific research develop").

C. mocks the scientists who improvise themselves historians in their hours of "erudition"; while also being no less severe with the philosophers.

If we are allowed one more digression, had the subject been instead of medicine, computer science, the main writer of 'historical summaries' that would have come to mind, as for the 20th century, and 21st now, is Donald Knuth. Knuth regularly accompanies his work with historical notes, indeed of a certain erudition. Especially visible in his magnum opus in many volumes [TAOCP].

Pascal's creator was also obviously concerned with the history of his own discipline.

To give another example, we consider the historical monograph by a former Eniac worker favorably, and as a typical product of its type or category i.e. com. scientist→historian.

(But there a lot of terrible 'historical overviews' out there being written by computer scientists, no doubt.)

But history, when it takes science for object, is no more than in other tasks a simple erudition. It is a representation of significations. ... what the science of the day calls error has a positive right to appear at the same title as what it holds for truth. What the scientist discards the historian recuperates [p. 158]

Definition of history as "representation of significations" is obviously influenced by semiology, which from p. 158 increasingly occupies a greater role in *La Formation*. In medicine, semiology - i.e. the science of signs - is linked or takes on the form of symptomatology - i.e. the science of symptoms, which here emerges further from p. 162 (sign of Argyll Robertson, etc.)

Another remarkable attempt at formalization in historical methods happens : a "reflex 1800" - corresponding to the final definition proposed in chapter 6 - is compared to a "reflex 1850"...

Later, this type of analysis is extended to other domains : e.g. "fermentation 1800", in the context of a comparison with Pasteur, and "epidemic 1800". (c.f. pp. 159-160) The full generalization of this approach is reached with the plain "concept 1800" (p. 161) to mean, depending on context, but here the state of the reflex at that given time.

The only higher level of generalization would be the formulation of a definition : a "concept n " designates the state of a given scientific concept at any n given time...

(Canguilhem himself does not go that far, but based on his propositions and gradual abstraction in the text it is the logical conclusion.)

Possibly this could be extended to philosophical or technological concepts, e.g..

Any attempt of formalization or generalization, any model of course implies some loss of detail. But one criticism is that this particular one implies a consensus at various points in history; which the history of the reflex itself seems to contradict. Or, it would be up to the historian to create such a consensus a posteriori, after the facts, in which case a certain degree of subjectivity is involved; and precisely the fallacies objected to.

Canguilhem asks whether his history covered the pre-scientific or the scientific stage of the reflex.

His first instinct - we wished to say reflex - is to look for answers in Bachelard, where else! The above distinction being drawn from him, of course.

Pflüger, who goes beyond Prochaska, is dedicated a more detailed coverage (ibid., having previously appeared in a footnote).

In the Bachelardian framework, Pflüger fits the category of "scientific", Prochaska "common".

On p. 161 Canguilhem attempts to use a third distinction established by Bachelard, in order to make sense of his object's evolution, in the period 1800 to 1850.

The neologism, term of *phenomenotechnical* is another notable proposition or innovation by Canguilhem. i.e. when a concept enables descriptions but leaves the books and enters the laboratories, and even there creates new instruments, it ceases to be phenomeno-logical and becomes -technical. (p. 161)

One of the last sentences of *La formation*, "We must look up to the hospital, up to the clinic, for the trace of the reflex 1850", announces the work of Canguilhem's student, Foucault. (p. 162)

Finally, Canguilhem examines popular culture and takes it seriously! This after having solely focused on scholarly, scientific, intellectual cultures.

"But we must go further still ... the reflex ... saw its scientific validity confirmed proportionally with vulgarization, in so far as the term of reflex exited scientific or medical vocabulary and passed into popular vocabulary." (p. 163)

Follows out of character but welcome sociological analyses, especially the stark conclusion :

"An industrial civilization cultivates the reflex reaction, whereas an agricultural civilization cultivates rather the slow or differed reaction." (p. 163)

In an industrial society the reflex is such a central notion due to increased rhythms of life it produces. Good reflexes are key to working environments of the industrial society.

And, what becomes of the reflex in the information society? Such is the directly following, logical question - not asked by Canguilhem in 1955.

The reflex there, we can continue, becomes more important due to the various devices that require quick and precise tactile command. As everything is turned into a computer, from cars to houses, so extends the reflex' domain.

Only when higher computers will begin to command subordinate ones, will the reflex cease to matter - as will likely humanity.

Ultimate ending passages see Canguilhem put aside the usual considerations of biology and medicine to engage once again with the significance of the reflex for society, including lines "the Taylorist fetishism of speed and uniformity", "the worker refuses practically to be mechanized" and prognostics like "the social subordination of human work to the exclusive service of machines". (pp. 165-166)

La formation ends unexpectedly with a multiple references, serving as final dedication, to Bachelard, author of the other *Formation*, in which his conceptions and views of history are endorsed. Canguilhem intends to do for biology what his predecessor had done in his own domain.

Commentary

Emerging clearly from conclusion, foreword and introduction (whose reversed order, like the turning over of Bergson, is full of insights) is that Canguilhem with *La Formation* has come to the defense of vitalism, and even animism, in a time of dominating and triumphant positivism and scientism; often rampant in their most vulgar and naive forms. Hence the critique of Descartes, and mechanism, and the re-appreciation, to not say appropriation, of Willis. (Conclusion is followed by translations of Willis, in an appendix called *Some texts of Willis, Presented and translated.*) Willis becomes the father of the reflex, with Canguilhem; Descartes stays the greatest French philosopher.

Canguilhem pleads for a science in which the imaginary still has a place, in spite of the modern environment of science, and the squeaky-clean laboratories. Bachelard's students know the imaginary is dangerous and fertile, and powerful probably because both; and the uncertain limit is that of the unconscious and conscious. *Indeed he had credited ~~the~~ power of imagination as the decisive*

Such a vision of science, which could be called inadequately maybe controlled-chaotic or cultured-poetic, has become elsewhere or afterwards fashionable under a variety of labels and slogans by authors with greater diffusion in the English-speaking world: Feyerabend, a supposed 'anarchist' take on science, the 'rejection of methods', etc. The bubblegum and coca-cola versions of starkly original and irreplaceable historians.

Before, we said that *La Formation* could replace Kuhn in the undergraduate circuit. The reading of Bachelard's *Formation of the scientific spirit* (the "other" *La Formation*, as we've called it, although it is really the first) is already and if not almost standard in the French curriculum.

Another influence that becomes obvious in the introduction is Merleau-Ponty who is credited with "hav[ing] procured a large audience in the French philosophical public" for the question. His work *La structure du comportement* is cited. Merleau-Ponty appears then again as a reference in the text (cf. chapter 7),

In Canguilhem's *The formation of the concept of reflex* there are two books:

1 - A history, written by a still relatively young historian: a history rebellious, unexpected, iconoclast of the subject matter.

2 - (We are still not sure which is more important) A defense of a certain way of writing history that is a large condemnation of the history of science as it has been.

And, how does one move on from such a work, with standards set so high for the history of science *as it should be conducted from now on* - a mastery of philosophy, history, multiple languages and the studied science —, such that everything else feels flat, and not have similar expectations for other authors, however condemned to disappointment?

The formation of the concept of reflex is one of few texts, if not the only one, that can be said the equivalent for the history of science of Dante's *Divine Comedy*. Conducted in a Christian fashion of sympathy with the condemned, based on a negative but authentic anthropology. We understand their sins, because their sins are ours. We feel for their plight, their plight could be ours. We root for Dante up to Paradise as we do for

* hence the multiple references in the text to not only Bachelard, the most poetic of all the historians of science, but also to Paul Valéry on two occasions: references that are rather unusual or exotic.

Canguilhem up to that last page 172. Beatrice appears in one case while a blinding, equally near inaccessible model for the history of science awaits in the other.

But the analogy is potent and can be further explored, with benefits to the understanding of a work that we do not assume to be easy : Bachelard is to Canguilhem like Virgil to Dante, a trusted guide left behind.

For our sinning scholars going through this book is a purgatory, a passage through flames, a prayer for shorter penitence, a journey indeed against inertia, with infinitely slowed down movements... (as are the penitents in the Purgatory serving sentences numbered in hundreds of years...)

Canguilhem's concern with logic, expressed elsewhere, but again in the introduction, ("even if one replaces the term of logic with a term currently more prestigious" e.g.), has a source that can not only be reasonably sought in Cavailles — who was the great absent of the Post-war period, having been one of the most promising philosophers of his generation — but also in logic's expansion, at a tipping point in the 1950s, and its settlements over ever greater parts of his discipline / philosophy.

Because we are moving ourselves on very uncertain grounds, with no maps useful for our terrain, here, elsewhere, and elsewhere, we are happy to find some of our intuitions here expressed - there confirmed :

"*Our study*", writes Canguilhem, has an "*intention that is very different*" from Fearing and those like him, it is to "*subordinate history to a critical examination of a question of methodology*". (Foreword, second page.)

Because Canguilhem is working on a philosophy of the history of science, and Fearing's is of another kind, there is no competition. In addition while Canguilhem's study has been called a "conceptual history", Fearing's can be called in turn a conceptually faulty one : according to Canguilhem the bias and flaw consists in that Fearing works from the point of view of the present judging the past, i.e. "the critique that the psychological physiology of today holds on that of yesterday" (ibid.).

In theory, this is where philosophers should have an advantage over both scientists and historians. It should be noted, by the way, that Canguilhem consistently continues to identify as a philosopher in the key elements and parts of *La Formation* that are the foreword and the conclusion, from beginning to end.

In the Foreword, he identifies as a "philosopher of biology"; In the conclusion he defends his area being the "philosophy of the history of science". (Page 1 and page 172.)

Powder needs a flame : Philosophy alone, likewise, is powerless, demanding more. And, in the worst case it is wet canon powder...

Double dedication of *La Formation* speaks to this condition of philosophy in its relations with the other disciplines :

"To Mr. Gaston Bachelard, philosopher. To Charles Kayser, physiologist. In testi-

Judging the past from the point of view of the present is one of the sins of our sinning scholars. Expressions "truth of the day", "science of the day" are repeatedly used.

The superiority of vitalism over mechanism in matters of animal movement and reflex is clear, or clearly defended (p. 128 and around).

It can serve at best as an intermediary form of knowledge (c.f. p. 123) "not the definitive form of knowledge in the matter"

Vitalism to make full sense of biology is better suited to give an account of the complexity of life. ~~is better suited to give an account of the complexity of life.~~

Finally, Berkeley is a sort of more metaphysical Willis, more on the side of philosophy, more of a philosopher... (p. 81 &.)

C. pays so much attention to Willis, Prochaska and Unzer because they are examples of vitalist or non-mechanist conception of life. (e.g. p. 107¹ with an inflection on p. 113) and a full confirmation (for Prochaska (p. 115) regarding Unzer)

|| permitting to Willis what was forbidden to Descartes || (p. 05)

In this particular differential proof, Croone is or becomes a Willis minus the imagination

Siblo
graphy
comment

* On the importance of transplants:
- p. 20-21 (Galen) "the capital event of modern times"
- p. 62 (Swammerdam)

→ Few texts give to the later such a meliorating feeling.
The appendix is not a disconnected addition but is used and referenced in the course of demonstrations in:

mony of great gratitude." (p. 8)

(the be

to chapter 3,

hence Introduction 4/5)

Text (obvious
ly in ch. 3) e.g.
p. 62-63

A constant and recurrent feature mark of Canguilhem's approach is the exact restitution of influences in a given thinker; and thereby produced enabled
(p. 117-24 are a good example)

~~c.f. p. 52, 60-61 [Descartes v Willis]~~
possibilities and limitations, in (p. 157-158) *
producing new thoughts and theories.
And, the careful comparison
~~This is of course done in a comparative~~
~~fashion~~ of authors in their various
components. Constellations leading to
different outcomes

~~c.f. p. 52, 60-61 [Descartes v Willis]~~
[Descartes, Aristotle, Galen]

Or, to explain possible bifurcations
or combinations of ~~traits~~ of
elements, strains
thoughts.

c.f. p. 49-50 ~~and~~ [ie. the ~~combination~~ apparition
in Baglivi of the terms reflex movement
inside of a mechanistic theory]
and 70 f. [Croone / Willis / Descartes] biology

Commentary

Already we proposed the idea that La Formation, akin to the Divine Comedy, was like a gallery of sinners — of scholarly sinners. Each with their own scholastic sins. If this comparison holds any truth, these are their deeds, and works...

By going through the bibliography, and the various chapters again, it occurred to us how much Soury, more precisely his landmark work on the nervous system, had been an important source of information, providing guidance, support for :

- in chapter 1 : Aristotle and Galen,
- in chapter 3 : Willis,
- in chapter 6 : Kant.

Soury in particular argued for the major role of Willis, an opinion in which he is also followed by Canguilhem; the former even claimed his contributions were everywhere hard to disentangle (c.f. p. 58).

A systematic analysis of Canguilhem's references to *The central nervous system* reveals these are limited to volume I and, there, to its first approximately 500 pages (the highest location reached is p. 485). Also, there is a natural progression in the pages cited that could point to a progressive, full reading (alternatively it is owed to the mere chronological succession of themes...).

From all this one is led to believe that C. had non-superficial knowledge of *The central nervous system* or that he put the index of that work, used methodically, to good use - as one should in general.

The bibliography is organized in such an overarching manner that it is split, in each of its sections, between A and B subdivisions corresponding respectively to the distinction, roughly, between primary and secondary sources (commentaries, essays etc.).

Among the former are the near endless "Opera Omnia" of our authors-doctors and even the *Encyclopedie* and its various articles. In the latter category are for example Leblonde's introduction to Book I of *On the parts of animals*, one commentary of a Platonic dialogue or Gueroult's important - and influential as we saw on Canguilhem - criticism of Descartes.

A variety of errors remain in the original edition, though we did not point them out always, systematically : this is found in the bibliography also e.g.

- Haller's work, on the same page, is found twice with different capitalization, for no good reason... (c.f. p. 197).
- Even more, Kant's "Träume eines Geistersehers, erläutert durch Träume der Metaphysik" features two different spellings for the same word, in the same sentence...
- the inconsistent use of p. vs. pp. (e.g. p. 199) or the exotic usage of "and", inside the French text, between Hoff and Kellaway (p. 200).

Bibliography ends on a section dedicated to the philosophy of science, where Canguilhem's previous book *La connaissance de la vie* (1952) is listed. Keeping in mind it is alphabetically ordered, contrary to previous ones, the following comments can be made : 1 - Bachelard's oeuvre stands above Canguilhem's 2 - It ends with *Cybernetics*.

Basic statistics on publishers found in the bibliography follows. C. warns that not all references from the text were included in the bibliography, this should be taken into account when reviewing the data.

Alcan	4
J.-B. Baillière	3
Germer-Baillière	2
Gallimard	6
P. U. F.	6
Vrin	4
Cambridge University Press	4
Oxford University Press	5

fig. notable publishers in La Formation

P. U. F., standing for Presses Universitaires de France, specializes in academic literature. They were the first publisher of this thesis in 1955. As was probably the norm or the regulation, at least for theses defended in Paris. (c.f. foreword or introduction, where Canguilhem expresses reservations about moving to Paris for his research).

Vrin is the reputed French publisher of philosophy books, with seat in Paris (near the old buildings of the University of Paris), and became La Formation's new home in 1977 after the first edition went out of stock.

Baillière specialized in medical texts (a family of publishers, J.-B. and Germer...).

In the first edition of *La Formation* (i.e. P.U.F., 1955) Canguilhem was credited on the cover as a - double - doctor in medicine and doctor in the humanities :

"Docteur en Médecine, Docteur ès Lettres"

At the time, La Formation was published as part of the "*Bibliothèque de philosophie contemporaine, fondé par Félix Alcan*" i.e. the Library of contemporary philosophy, founded by Félix Alcan.

In the 1977 Vrin edition it became a part, as the cover at the top indicated, of "*L'histoire des sciences, Textes et études*" i.e. The history of sciences, texts and studies. [While the original was just the standard, generic P.U.F. cover,] the cover here featured a statue of Copernicus (a drawing reproduction of Torun monument, Poland) :

Hence, echoing one of the main or most striking theses of the book, about the shift to the study of the nervous system / spinal cord representing a revolution similar to that of heliocentrism, as for the reflex. The provoked decentralisation, from head-centric or heart-centric explanations, having played a role similar for the establishment of correct knowledge against faulty reasoning or prejudiced beliefs, including metaphysics and the

peculiar certainty that inhabits some doctors, which only a better knowledge of history could correct.

Yet, their predecessors and ancestors viewed the heart or the head as the center, for a variety of causes, with the same ardent belief of correctness, of their own superiority and forever right to truth, as those - now mocked and delegated to a dark part and past of humanity, never, ever to be repeated - who once viewed the Earth as, necessary, center.

Religious injunctions, "It is so, because God said it so", and tribunals seemingly disappeared; or rather were replaced and became more diffuse, in areligious forms of classrooms, peer conformism, professional hierarchies and the evident implication "It is so, because it's always been so", "Because the Oberartz said so", "Because the doctors of the General Hospital of Vienna said so"... leading to Semmelweis' terrible fate, who could only be wrong, if all others had said so, as they had... — in which no organized religions played a role, except for science's own dogma.

Our recommendation to include this book in the curriculum, is not limited to the sole satisfaction and pleasure of historians or philosophers, but extends to students of medicine and doctors. At worst the former could find in such a book, wrongly, but that is not the point, a sentiment of their own superiority. At best the latter, much more importantly, would derive from it a life-saving humility.

In *La Formation*, Canguilhem warns before judging the past from a present point of view. But, in turn, one can only hope — though with a certain limited optimism, always — that a knowledge of the past can help ameliorate the present.

errors,
inconsistencies of the original:

- 9/18 : hermes v. hermès
- 25/195: "Collection Hip." v. italics
- 54 n. 5 : apparent lack of closing parenthesis.
- 58 n. 2 : Medecin[?]]
- ~~129 reverse of pages~~
- 143 : missing closing quoting mark.

index (notions)

- | | |
|---|--|
| <ul style="list-style-type: none">- spinal cord :- brain- heart- frog- fire :- anencephal- fetus :- rabbit- dog- cat- guinea pig- marrow | <ul style="list-style-type: none">- Copernic revolution- Ptolemaic astronomy- reflex arc |
|---|--|